Article

The project-based learning (PBL) integrating the framework *Scrum*

El aprendizaje basado en proyectos (ABP) integrando el marco de trabajo *Scrum*

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Abstract

Currently, Project-Based Learning is a strategy that is frequently used in the educational field at all levels. This allows the development of knowledge, skills and attitudes that guarantee meaningful learning. On the other hand, when thinking about a project, the agile approach has been efficient to achieve success in managing them. The research presents an inductive-deductive study with the aim of integrating the Project-Based Learning strategy (PBL) and the Scrum framework. With this, juxtapose the benefits of the agile approach that allow simultaneously achieving successful projects and meaningful learning. The adopted methodology consists of two steps, the first consisting of a theoretical framework that supports the primary concepts of the study and, successively, the second involves the proposed Project-Based Learning (PBL) and Scrum integration model. Contributing, mainly as a contribution to the line of knowledge generation in the scientific field of the implementation of Scrum for life with an academic-educational approach.

Project-based learning, *Scrum*, Strategy

Resumen

En la actualidad, el aprendizaje por proyectos es una estrategia que se emplea frecuentemente en el ámbito educativo en todos sus niveles. Ésta permite el desarrollo de conocimientos, habilidades y actitudes que garantizan el aprendizaje significativo. Por otro lado, cuando se piensa en un proyecto, el enfoque ágil ha resultado eficiente para conseguir el éxito en la gestión de estos. La investigación presenta un estudio inductivo-deductivo con el objetivo de integrar la estrategia de aprendizaje basada en proyectos (ABP) y el marco de trabajo Scrum. Con ello, yuxtaponer los beneficios del enfoque ágil que permitan conseguir simultáneamente proyectos exitosos y aprendizaje significativo. La metodología adoptada consta de dos pasos, el primero compuesto de un marco teórico que fundamenta los conceptos primordiales del estudio y, el segundo envuelve el modelo propuesto de integración del Aprendizaje basado en proyectos (ABP) y Scrum. Contribuyendo, principalmente como un aporte a la línea de generación de conocimiento en el campo científico de la implementación de Scrum para la vida con un enfoque académico-educativo.

Aprendizaje basado en proyectos, *Scrum*, Estrategia

† Researcher contributed as first author.

Introduction

Project-Based Learning (ABP in spanish) or better known as *Project-Based Learning* (PBL) is a learning strategy aimed at the students as responsible for their own learning and where knowledge has the same value of importance as the achievement of skills and attitudes. The PBL develops a project collaboratively. A project is the set of activities articulated with each other, in order to generate products, services or satisfy needs or concerns, considering the resources and time allocated.

This study is an integrating proposal of project learning approaches and agile project management applying the use of the *Scrum framework*. It is important to mention that although *Scrum* was initially created for software development, it has evolved, and several studies support its effectiveness in any area, including life projects (*Scrum* for life). In this sense, the main objective of this study is the integration of the *Scrum framework* with the learning strategy in projects, and with it, juxtapose the benefits of the agile approach that allow successful projects and significant learning to be achieved. Based on the above, applied research is carried out following the five constructive moments of project learning and detailing for each of them, the respective *Scrum* activities and events that build a new learning model.

This is divided into three main sections:

a) Theoretical framework, in which the steps taken to develop the research are specified.

b) Development of the Methodology includes the detailed description of the activities carried out in each step of the methodology followed. In addition, the findings found from each step.

Theoretical framework

Project-Based Learning (PBL)

Project-based learning (PBL) is the didactic use of a project, which must be planned, created and evaluated, in small groups of students, in order to respond to the needs raised in a given situation.

Project-based learning is a methodology that is developed in a collaborative way that confronts students with situations that lead them to propose proposals in the face of a certain problem (Cobo Gonzales & Valdivia Cañotte, 2017).

Based on this we can discern that a project is a set of activities articulated with each other, this with the purpose of generating products, services or understandings capable of satisfying both concerns, needs and problems in relation to the resources linked and time allocated.

Project-Based Learning encourages students to organize themselves, over an extended period of time, around an objective based on a complete question, problem, challenge or need (Ministerio de Educación, 2019).

It can be approached from different points of view and areas of knowledge with the intention of promoting interdisciplinarity. PBL presents a learning model with which students actively work, plan, implement, and evaluate projects that have real-world application beyond the classroom (Latorre Cosculluela, 2021). Figure 1 shows the Phases and actions of the Project-Based Learning strategy.
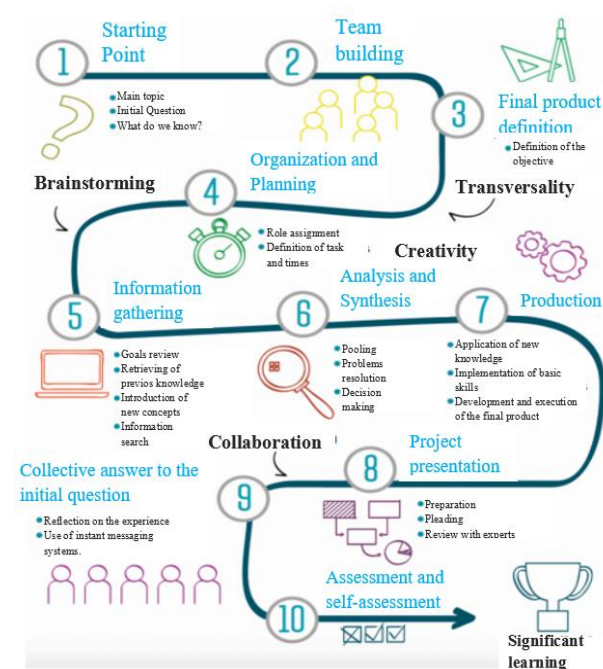

Figure 1 Phases of Project-based learning
Source: (Hernando, 2015)

The agile approach or agility

Today, the Agile approach has expanded rapidly, including in the area of project management. Agile project management is a project management style that focuses on early delivery of business value, continuous improvement of Project products and processes, scope flexibility, team input, and delivery of well-tested products that reflect customer needs. Agile Project Management is called a set of methodologies that allow the development of projects that require special speed and flexibility in their process and especially, those developed in environments where we find very high uncertainty.

Framework Scrum

Scrum is a project management framework which people can try and solve complex and adaptive problems, while productively and creatively delivering products with the highest possible value. Its main features are that it is lightweight, simple to understand, and extremely easy to dominate.

Scrum is a tool used by companies to create various types of software. However, some time ago it has being implemented not only in companies for the creation of software, but also as a didactic tool in schools, institutes and universities, as is well known, it is an agile methodology which is used to create group and collaborative work. In addition, if we add the supervision and guidance of a teacher or expert on the subject, students can be helped to develop projects, ensuring their best quality on it.

The application of the *Scrum* methodology in education can bring advantages to students, in addition to providing motivation to improve their critical thinking skills, strengthening and developing their communication skills by making innovative and attractive proposals.

Scrum, which name does not correspond to an acronym, but to a sports concept, typical of Rugby (related to the training required for the rapid recovery of the game in the event of a minor infraction), is an agile development model characterized by (Navarro Cadavid, Fernández Martínez, & Morales Vélez, 2013):

- Adopting a strategy of incremental development, rather than full product planning and execution.

- Basing the quality of the result more on the tacit knowledge of people in self-organized teams than on the quality of the processes used.

- Overlapping of the different phases of development, instead of carrying them out one after the other.

Scrum is an agile project management methodology, founded on the principles of a learning organization. The principles of a learning organization are systems thinking, personal mastery, mental models, shared vision, and team learning. However, if organizations follow Scrum practices without understanding the underlying principles, Scrum does not work as well as expected. Therefore, it is necessary to attend to the Scrum principles in your practice to apply it effectively Apud. (Harrison & Thackeray, 2020).

Scrum consists of three phases: Pre-game, in some other texts such as Planning, Development Game or Development and Post-game or Completion (Chimarro Chipantiza, Mazón Olivo, & Cartuche Calva, 2015). Figure 2 shows the *Scrum* lifecycle.
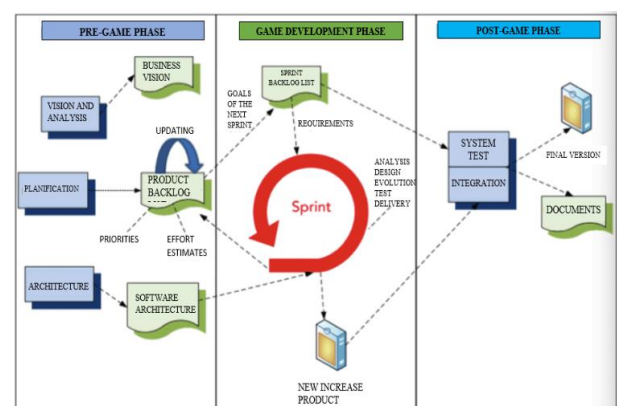

Figure 2 The *Scrum* lifecycle
Source: (Chimarro Chipantiza, Mazón Olivo, & Cartuche Calva, 2015)

Development of the methodology

Based on the theoretical foundations presented, a deductive, non-experimental analysis of the integration of Project-Based Learning (PBL) and *Scrum* is carried out below.

The analysis starts from the PBL and *Scrum* phases (see Figures 1 and 2). This analysis is carried out using the Delphi Technique. This technique collects the information that a group of experts, previously selected, has on a certain topic. According to Montañés Serrano, the procedure to apply the technique is as follows (Montañés Serrano, 2009):

- Experts are selected.

- They are contacted and the operation is explained.

- A questionnaire is prepared with the questions that are interesting to know.

- The questionnaire is sent to the experts, indicating the deadline for sending the answers.

Table 1 shows the group of experts established to carry out the integration correspondence analysis between the PBL and *Scrum* phases.

Identifier Maximum degree of studies	Affiliated Educational Institution
Expert 1 Master in Information Technology Management	Universidad Autónoma de Campeche. Professor and researcher at the Faculty of Engineering. Responsable for Examination Support EGEL+D-ISOFT
Expert 2 Master in Pedagogy	Universidad Autónoma de Campeche. Professor and researcher at the Faculty of Engineering. Academic link unit.
Expert 3 Master in computer science	Instituto Tecnológico Superior de Hopelchen. project division
Expert 4 Master in Educational Technology	Instituto Tecnológico de Campeche. Head of computational and systems department
Expert 5 Doctor's degree in Computer Science	Universidad Autónoma de Campeche. Academic Secretariate of the Faculty of Engineering.
Expert 6 Doctor's degree in Computer Science	Universidad Autónoma de Campeche. Head of the Computational Engineering Center

Table 1 Group of experts for the Delphi Technique. Correspondence analysis between PBL Phases and Scrum
Source: Own elaboration

Table 2 shows the questionnaire defined for the application of the Delphi Technique.

ID	Questions
	Full name: E-mail (institutional priority): Educational Institution which belongs: Current title or position: Maximum degree of study: Be specific: Teaching experience: (in years): Assignment of classes in group:
1	Which of the following options define significant learning?
2	Which of the following options define a learning strategy?
3	Which of the following options define a Project?
4	Have you used the Project Based Learning in the teaching performance?
5	Have you used in your teaching process the framework *Scrum*?
6	The degree of familiarity you have with respect to the use or application of the *Scrum* Framework is:
7	Do you consider, according to his teaching and professional experience, that the Phases of Project-Based Learning (PBL) can correspond to the Phases of the life cycle of the Scrum Framework?
8	If your previous answer was yes. Match, based on your knowledge and teaching experience, the Phases of Project-Based Learning (PBL) with the Phases of the life cycle of the *Scrum* Framework
9	Have you used the Scrum Framework as a learning strategy?
10	Do you consider, based on your teaching and professional experience, that the Scrum Framework can be used as a learning strategy? Why:

Table 2 Questionnaire designed for the Delphi Technique
Source: Own Source.

As a result of the Delphi Technique, Table 3 shows the correspondence mapping identified for integration between PBL and *Scrum*.

Phases of Project-Based Learning (PBL)	Phases of the *Scrum* framework
1. Starting point - Initial question - Main topic - What do we know?	1. Identification of the problem or necessity
2. Team Building	2. Team building
3. Definition of the final product - Purpose definition	3. Definition of the objectives and scopes of the Project - Vision
4. Organization and planning - Roles Assignment - Definition of tasks and times	4. Organization and planning - Roles Assignment - Creation of the Product List (priorities and estimates)
5. Information gathering - Review of objectives - Gathering of previous knowledge - Introduction of new concepts	5. Information gathering
6. Analysis and synthesis - Sharing - Problem resolutions - Decision making	6. Analysis and synthesis - The Planning (Sprint Planning) - Software Architecture

7. Production
 - Enforcement of new knowledges
 - Implementation of basic skills.
	7. Production
	 - Sprint Backlog
	 - Sprint
	   o Daily meeting (every 24 hrs)
	   o Review meeting of each iteration (Sprint)
	   o Retrospective meeting of each iteration (Sprint)
	 - New product increased
	 - System tests
	 - Integration

8. Project performance - Preparation - Defense - Review with experts	8. Project performance - Version of the final product - Documents
9. Collective answer to the initial question. - Thinking of the experience - Use of instant messaging systems.	9. Project delivery and closure. - Retrospective of the Project.
10. Evaluation and self-evaluation.	10. Evaluation and self-evaluation.
Significant learning	**Successful Project**

Table 3 Correspondence analysis between PBL Phases and *Scrum*. Source: *Own Source.*

Results

Finally, after specifying the adaptability and integration of Scrum with PBL, the activities proposed in each phase are detailed:

- *Starting point*. According to the subject to work and the disciplinary area in question, students must identify the need or problem in a company or organization to define the new project.

- *Team building*. The formation of student teams for the development of the project is at the teacher criteria. It can be allowed to the students themselves to integrate their teams with a maximum number of members, and even with specific rules such as including a certain percentage of women and men, among others.

- *Definition of the final product*. This Phase involves the Vision of the Pre-Game phase of the Scrum life cycle, taking as input the initial idea of the product that the interested parties have Id. (Chimarro Chipantiza, Mazón Olivo, & Cartuche Calva, 2015).

- During this stage, the personal criteria that the student has of a topic and those found in the documents reviewed, the socially accepted knowledge, are confronted. At this stage you must have an exact and accurate knowledge of the Scrum methodology. Experts recognize the need to consult *The Scrum Guide* as a mandatory theoretical basis. (Schwaber & Sutherland, Noviembre de 2020).

- *Information gathering*. In this phase, the first guiding ideas or guidelines for a proposal are established, expressing them in a concrete, graphic, verbal or pictorial way. In this sense, the Pre-phase of the *Scrum* life cycle is concerned:

  - The Planning. This is the definition of the product to be built. For this, the Product Backlog is created based on the current knowledge of the system. Prioritized requirements are formulated, and the necessary effort is estimated. The Product Backlog is constantly updated with more accurate estimates and changes in the priority of items on the list.

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- Architecture (The Architecture/High Level Design). The product design is planned from the Product Backlog. The changes necessary to implement the items that appear in the Product Backlog and the impact that the changes may have are identified. A Design Review Meeting is held to review implementation goals and make decisions based on the review. Preliminary plans are prepared on the content of each deliverable (Release). The output of the Pre-Game Phase has the Product Backlog and the Architecture.

- *Analysis and synthesis*. During this phase, a convenient way is sought to represent the socially acquired knowledge within the production company, that is, the team, which allows the understanding of the subject by the other group members. Here is how the deliverable should be produced.

- *Production*. This stage corresponds to the moment in which the team externally represents the knowledge acquired in the previous stages. In this phase, skills for coexistence and cooperative work must be strengthened. The Game or Development phase of the Scrum life cycle is included, it is the agile part of the framework and takes as input the Product Backlog. The product is developed in the iterative and incremental cycle of Scrum, based on the Sprint.

- *Presentation of the project*. Consider the Post-Game of the Scrum life cycle, it contains the closure of the deliverable (Release). To enter this phase, it is necessary that the requirements set out in the Product Backlog have been completed. The final product will be ready to be delivered and here the integration, system tests and documentation are carried out.

- *Collective response to the initial question*. It covers the retrospective of the project and the Lessons Learned.

- *Evaluation and self-evaluation*. It is the last phase and with the phase according to the teacher's guidelines, a presentation in front of the group and even school authorities is recommended. The evaluation rubric is left to the teacher's consideration. It is important to mention two considerations: the presentation of the project and its product (deliverables).

Thanks

Conclusions

To conclude, the ABP is a student-oriented learning strategy which manages to acquire knowledge in a self-taught way, these students form teams to develop projects to generate products, services or satisfy the client in relation to the linked resources and time allocated.

Scrum is not only used for software development, but also to carry out life projects, with the main objective of integrating the Scrum framework with the project learning strategy, all this following five constructive moments of project learning and detailing for each of them, the Scrum activities, and events.

Another definition for PBL is that it encourages students to organize themselves for an extended period of time focused on an objective based on a complete question which can address different points of view and areas of knowledge with the intention of promoting interdisciplinarity.

Agile project management is known as a set of methodologies that enable rapid and flexible project development, focused on early delivery of business value, continuous improvement of project products and processes, and delivery of well-tested products that reflect customer needs.

On the other hand, Scrum is a project management framework where people can deal with and solve complex and adaptive problems, productively and creatively delivering products with the best possible value.

Although Scrum is a tool for creating software, it is currently implemented as a didactic tool in schools, colleges and universities, which helps create group and collaborative work, when combined with the supervision and guidance of a teacher or expert on the subject, it can help to develop good quality projects, bringing advantages to students as well as motivating them to improve their critical thinking and strengthening their communication skills.

Taking all this into account, a deductive, non-experimental analysis of PBL and Scrum is made, taking into account each phase of both methodologies using the Delphi technique in which a group of experts have a certain topic, what must be done is first select the experts, then contact them and explain their role, each one having a role, a questionnaire must be prepared with the questions of interest to them, once the questionnaire is completed it is sent to the experts with the deadline to respond, for this reason it is divided into tables to show the correspondence analysis of the members between the PBL and Scrum phases, in another table show the questionnaire applying the Delphi technique and finally, in another table show the answers obtained and assigning the correspondence identified for integration between PBL and Scrum.

References

Harrison, N., & Thackeray, L. (2020). eaching Systems Thinking as a Foundation of Scrum," 2020 Intermountain Engineering, Technology and Computing (IETC). 1-6. doi:10.1109/IETC47856.2020.9249111

Chimarro Chipantiza, V. L., Mazón Olivo, B., & Cartuche Calva, J. J. (2015). *La usabilidad en el desarrollo de software.* Universidad Técnica de Machala.

Cobo Gonzales, G., & Valdivia Cañotte, S. (2017). *Aprendizaje basado en proyectos (5.a ed.).* Perú: Universidad Católica del Perú.

Hernando, A. (2015). *Viaje a la escuela del siglo XXI.* Fundación Telefónica. Obtenido de Escuela con cerebro.

Latorre Cosculluela, C. (2021). *El docente del siglo XXI : enfoques y metodologías para la transformación actual.* España: Prensas de la Universidad de Zaragoza.

Ministerio de Educación. (2019). *Metodología de aprendizaje basado en proyectos.* Unidad de Currículum y Evaluación.

Montañés Serrano, M. (2009). *Metodología y técnica participativa. Teoría y práctica de una estrategia de investigación participativa.* (Editorial UOC ed.). Barcelona, España: Editorial UOC.

Navarro Cadavid, A., Fernández Martínez, J. D., & Morales Vélez, J. (2013). Revisión de metodologías ágiles para el desarrollo de software. *Prospectiva, 11*(2).

Schwaber, K., & Sutherland, J. (Noviembre de 2020). *La Guía de Scrum: La Guía Definitiva de Scrum: Las Reglas del Juego.*