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RESEARCH ARTICLE

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DesignScrum–An agility educational resource powered by creativity

Carlos Villarrubia | **Juan Manuel Vara** | **David Granada** | **Cristian Gómez-Macías** | **Francisco Javier Pérez-Blanco**

Computer Science & Statistics Department, Universidad Rey Juan Carlos, Madrid, Spain

Correspondence
Carlos Villarrubia and Juan Manuel Vara, Computer Science & Statistics Department, Universidad Rey Juan Carlos, Calle Tulipán S/N, Móstoles, Madrid, 28933, Spain.
Email: carlos.villarrubia@urjc.es and juanmanuel.vara@urjc.es

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Abstract

Agile methods have been widely adopted by the industry and its teaching has seen a surge, particularly in the software development field. However, these methods have a number of limitations which affect product outcomes, such as the fact that many software development companies now use Scrum to get developers to work without interruption between iterations, rather than to maintain a sustainable rhythm. Agile experts have stated the importance of incorporating creativity into Scrum, and although there are several agile resources that help with the learning process, it seems essential to approach such learning from a practical point of view. Furthermore, none of these resources introduce creativity. In this paper, we present an educational resource in the form of a serious game that allows you to acquire all the key concepts of agile and creative methods. The game is based on the use of LEGO pieces to simulate a real project, applying the key concepts of the Scrum and Design Thinking frameworks in a gamified way. It was assessed in a professional training centre of computer science by using surveys through which participants evaluated their previous knowledge of agile and creativity methods. We analysed the improvement of these competences, as well as the general level of satisfaction with the game. After the game, the results showed that the participants' knowledge of the Scrum and Design Thinking frameworks had improved and that they were very satisfied with the whole experience.

KEYWORDS

agile, creativity, design thinking, education, gamification, scrum

1 | INTRODUCTION

In recent years, the application of agile methods to software projects has boomed due to the uncertainty and number of changes that these projects increasingly face. This is usually due to the technology being used, the nature of the software requirements and the preferences of the customers.[1]

AQ, Assessment questions; ANOVA, Analysis of variance; ICC, Intraclass correlation coefficient; IQR, Interquartile range; SD, Standard deviation; XP, eXtreme programming.

The positive results obtained from the application of agile methods in organisations which previously used more traditional approaches have pushed the software industry to continue applying this type of practices which, from the outset, allow for significant reductions in costs and time spent.[2,3] These methods have no negative impact on the quality of the projects, which in some cases has even increased, leading to a subsequent improvement in customer satisfaction.[3]

A specific example of this improvement is the Scrum working framework created by Ken Schwaber and Jeff Sutherland in 2002, which is based on delivering value to customers through short iterations, while the development team is multifunctional and self-organising at all times.[1,4] Clearly, teams must learn to apply agile methods to their projects if they are to achieve these positive results. This requires appropriate training which enables people to learn the relevant concepts (knowledge) and, most importantly, their application to successful software project management (know-how).[5] In this context, it is important to emphasise that frameworks such as Scrum are not difficult to learn on a conceptual level, as they are reference frameworks that contain a limited number of concepts and ideas.[6]

The complexity of mastering frameworks such as Scrum lies in training teams to effectively apply agility within their organisations. In order to promote this aspect, new teaching methods have been developed in recent years, which even aim to find entertaining approaches. For example, Scrum can be learnt through the educational game LEGO4Scrum, which uses LEGO pieces;[7] The Ball Game, which uses rubber balls;[8] or Card Game PlayScrum, which uses cards.[9]

Several studies have shown that learning the theory of development processes with constant interruptions by the teacher to point out mistakes, while reinforcing the process with a learning game, enables the learner to acquire knowledge better.[10,11] However, while there are several proposals that cover the different key aspects of Scrum training, there are currently very few educational games that enable the acquisition of all the key concepts of this framework.

On the other hand, despite the advantages of agility, these methods have limitations which affect the product outcome because many software factories use Scrum to push developers towards working with no interruption between iterations instead of maintaining a sustainable rhythm.[12] In addition, many organisations typically add as many user stories to the iterations as they want, so that they can later be filtered by priority, making the Scrum process largely inefficient.

These limitations have led agile experts to identify the need for some improvements to Scrum. Some of the most widely accepted suggestions for improving Scrum are: introducing rest periods, a refactoring iteration or a starting event to design the iteration.[13] A good example of the latter could be the Design Thinking method, which consists of iteratively generating new ideas and concepts through five stages that encourage out-of-the-box thinking.[14] However, a recent study revealed that current proposals fail to incorporate creativity into Scrum to address these limitations.[15]

All this given, the main objective of this work is to introduce DesignScrum, a game-like educational resource for agile teaching that is powered with creativity and aims to teach the key concepts of Scrum and Design Thinking, through gamifying different events and stages that form them. To this end, we have carried out a study of the existing proposals to define a comprehensive Scrum teaching game powered with creativity. The existence of many other techniques that can be incorporated into the Scrum framework enables these concepts to be learnt by slightly modifying the framework. For example, the complementary techniques Triangulation[16] or Brainstorming.[17] This educational resource is complemented using several techniques like the Kanban board or the Starfish retrospective. In this educational resource, we aim for participants to learn how to apply Scrum and Design Thinking facing everyday situations which come up in software projects, such as being part of a team that is working on a different project. We reached a draft validation through an empirical pilot study with students in their second year of Higher-Grade Professional Training in Networked Computer Systems Management.

As a consequence of this objective, we have defined a set of assessment questions (AQ) that are aligned to this objective. More specifically, the first subset of questions was created to find out whether DesignScrum generally enables students to acquire the key agile concepts, as well as to promote creativity. The second subset of questions focuses on discovering whether introducing creativity implies a lower degree of learning amongst participants. The wording of all the assessment questions for both subsets can be found in Section 5.3.

The remainder of the paper is structured as follows: Section 2 describes the background that was studied prior to conducting this work; Section 3 explains the research method used to create the educational resource developed; Section 4 presents the developed educational resource; Section 5 presents the experiments run to evaluate the educational resource developed; and finally, Section 6 summarizes the main conclusions derived from this work.

2 | RELATED WORK

Gamification consists of designing an attractive game that enables students to achieve certain goals with as few elements as possible and a variety of features. This is possible because gamification can include elements of games in activities that are not games, and it can adapt to educational contexts.[11,18] These characteristics enable gamification to bring about a positive change in players' behaviour and attitudes, thus improving their motivation and the learning process.[19]

There are currently a large number and variety of educational resources that use gamification to teach agile principles. These resources usually take Scrum as their reference framework, so they focus on students being able to Reference 15:

1. Learn key Scrum concepts.
2. Understand and differentiate between Scrum events, artefacts and rules.
3. Apply Scrum correctly to specific situations in a software project.

Most of these educational resources are used as games because they incorporate game design elements and techniques, although they are used in an educational context that is not a game. These are implemented as an integrated experience through the various smaller components of the game. The game components or elements can be objects, relationships between objects or abstract concepts. For example, in the game of checkers, the objects are represented by the pieces (pawns or checkers), the relationship between objects is the rule regarding how to get past the pieces, and the abstract concept is how to gain an extra checker when pawns reach the opposite end of the board.[18]

There is a growing number of software organisations that are gamifying their internal systems and practices. However, most of these organisations are not applying best practices because they are gamifying the mechanics in a simple and superficial way (points, pins and leaderboards). To address these issues, game designers should pay more attention to the underlying psychological dynamics that make gamification attractive.[20] In addition, these designers should incorporate creative elements into the games to stimulate players' imaginations and encourage their active participation in the gaming experience.[21]

Table 1 shows a comparative analysis of some of the most representative educational resources which have been studied in the context of this paper and which are used as games due to their gamification. We considered an educational resource to address events, roles, artefacts and skills (multi-functional and self-organised) if they were fully covered. Furthermore, game actions were considered to be related to the resource if they covered situations such as team changes, special situations regarding requirements, effort estimation, etc. Finally, the resource was considered to promote creativity if it contained a creative element or technique.

This table shows that most of the educational resources enable students to gain some knowledge about agility. We found that 55.88% of these resources covered all Scrum events, 50% addressed the three roles, 76.47% addressed the different artefacts, 91.18% covered the skills, 50% addressed some game actions, and 61.76% had some focus on a complementary agile technique. These educational resources were enriched with complementary techniques, specifically: the Kanban board in 17.65% of cases, Burndown chart in 35.29%, the Planning poker in 11.76%, and Burnup chart in 5.88% of cases. In addition, 41.18% of educational resources were not based on good practices within the Scrum working framework.[4] Instead, they used other proposals to introduce agile principles[46] found in the resource. Finally, most relevant creativity was not covered in any of the 34 educational resources which were assessed.

The full version of this table is available online,* where we have included information on whether the educational resource covered all the different components and elements of the game.

Although other proposals were identified during the literature review, they were not included because they do not enable the capture of a large number of key agile concepts. In other cases, the same paper contained several proposals, such as Equilateral triangles and Scribble of the process.[27] We must also bear in mind that the search for proposals is a never-ending task, as new agile educational resources are constantly appearing, or initiatives to reconstruct agility are being born, such as Agile 2 by Cliff Berg et al.[47] or Rethinking Agile by Klaus Leopold.[48]

Most of the studies analyzed focus on learning environments within the field of informatics. Some papers, such as The Bug is a Lie,[44] ScrumTutor[37] or Virtual Scrum,[33] have developed a programme to teach the agile method. Kanban Pizza Game,[22] LEGO4Scrum,[7] XP Game[24] or Pass the Pennies[22] are different to most proposals in that they focus on teaching agility through different concepts to those used in Scrum, Kaban or eXtreme Programming.

*Dataset DOI: http://dx.doi.org/10.17632/dztyr22chx.2.

TABLE 1 Elements and techniques of the assessed educational resources.

Agility							Creativity	
Educational game	**Events**	**Roles**	**Artefacts**	**Agile skills**	**Game actions**	**Agile techniques**	**Creative stages**	**Creative techniques**
The ball game[8]	—	—	×	×	—	Burndown chart	—	—
Pass the Pennie[22]	—	—	—	×	—	Kanban board	—	—
Card Game PlayScrum[9]	×	—	×	×	—	—	—	—
Scrum for[1] hell[23]	—	—	—	×	—	—	—	—
XP Game[24]	—	—	—	×	×	Burndown chart	—	—
SCRUM-X[25]	×	×	×	—	×	Burndown chart	—	—
The Marshmallow Challenge Game[26]	—	—	—	×	—	—	—	—
Equilateral triangles[27]	—	—	—	×	—	—	—	—
Scribble of the process[27]	—	—	—	×	—	—	—	—
Build Your Own Scrum[28]	×	×	×	×	×	Infinite possibilities	—	—
The Scrum Board Game[29]	×	—	×	×	×	—	—	—
Scrum Paper City[11]	×	×	×	×	—	—	—	—
LEGO4Scrum[7]	×	×	×	×	×	Burndown chart	—	—
Extreme Construction[30]	×	×	×	×	×	—	—	—
SCRUMIA[31]	×	×	×	×	×	—	—	—
Scrum Sim[32]	×	×	×	×	×	Planning poker Burnup chart Burndown chart	—	—
Virtual Scrum[33]	×	×	×	×	×	Planning poker Kanban board	—	—
[2] Featureban[34]	—	×	—	×	×	Kanban board	—	—
Origami[35]	×	×	×	×	×	Planning poker	—	—
Sprint, then fly[36]	×	×	—	—	×	—	—	—
ScrumTutor[37]	×	×	×	×	—	—	—	—
Multitasking[3] Name[22]	—	—	×	—	—	—	—	—
Don't Break the Build[38]	×	—	×	—	—	—	—	—
Training Scrum with Gamification[39]	×	×	×	×	×	Planning poker	—	—
Scrumify[40]	×	×	×	×	—	—	—	—
Kanban Pizza Game[22]	—	—	—	×	—	—	—	—
Relax, It's a Game[41]	—	—	—	—	—	Burndown chart	—	—
SCRUMI[42]	×	×	×	—	—	—	—	—

(Continues)

TABLE 1 (Continued)

Agility							Creativity	
Educational game	**Events**	**Roles**	**Artefacts**	**Agile skills**	**Game actions**	**Agile techniques**	**Creative stages**	**Creative techniques**
Scrum simulation game[43]	×	×	×	×	—	Kanban board Planning poker Burndown chart	—	—
Use of Gamification to Teach Agile	—	×	×	×	×	Planning poker	—	—
Values and Collaboration[11]						Burndown chart		
The Bug is a Lie[44]	×	×	×	×	—	Burndown chart	—	—
SimScrumF[45]	×	×	×	×	×	Kanban board	—	—

[1] Originally in https://xp123.com/articles/scrum-from-hell/.
[2] Originally in https://www.agendashift.com/resources/featureban.
[3] Originally in https://www.crisp.se/gratis-material-och-guider/multitasking-name-game.

In conclusion, these proposals aim to present one or more agile concepts in detail, and sometimes show differences between existing proposals. According to the analysis of these proposals, and in contrast to the educational resource presented in this document, very few of the proposals enable the acquisition of all the key concepts of agile methods, and none of them include aspects that foster creativity. This may be because most of these resources were developed to teach specific agile concepts, or because the authors felt that introducing more agile concepts could increase the complexity of putting the proposal into practice.

3 | RESEARCH METHOD

The research process used to develop this work was the Design Science method. This method, divided into six stages, is based on building a living artefact that contains the solution to the identified problem through iterative improvement. Figure 1 provides a schematic summary of the research process used to carry out this study and includes a brief description of the outcome of each stage. The Design Science research method was chosen because it focuses on the design of experiments[49] and was appropriate in our case due to the need for experimentation in this work. The stages of this method and the result obtained at each stage were as follows:

1. **Identify problem & motivate:** as a result of several software development project management, it was observed that the development team was confused about the concepts of agile project management, despite the efforts of agile experts to clarify these concepts. This, coupled with the fact that, as shown in Section 2, there was no single educational resource that allowed for the acquisition of all agile concepts and that none of them were enhanced with creativity, encouraged the authors of this work to seek a solution to the problem.
2. **Define objectives of a solution:** the solution was to define an agile educational resource that would enable the acquisition of all agile concepts in software project management, while encouraging the development of disruptive products through creativity. The aim was to provide educators with a single resource containing all the necessary elements to teach these concepts in a way that would reduce the potential for confusion between concepts among students.
3. **Design & development:** the development process included the creation of materials, the implementation of game dynamics and the inclusion of components designed to teach the concepts of Scrum and Design Thinking. Aspects such as user experience in the game and player motivation were also taken into account. Each element of the game was carefully selected to maximise the transfer of knowledge and practical skills. Several iterations were carried out

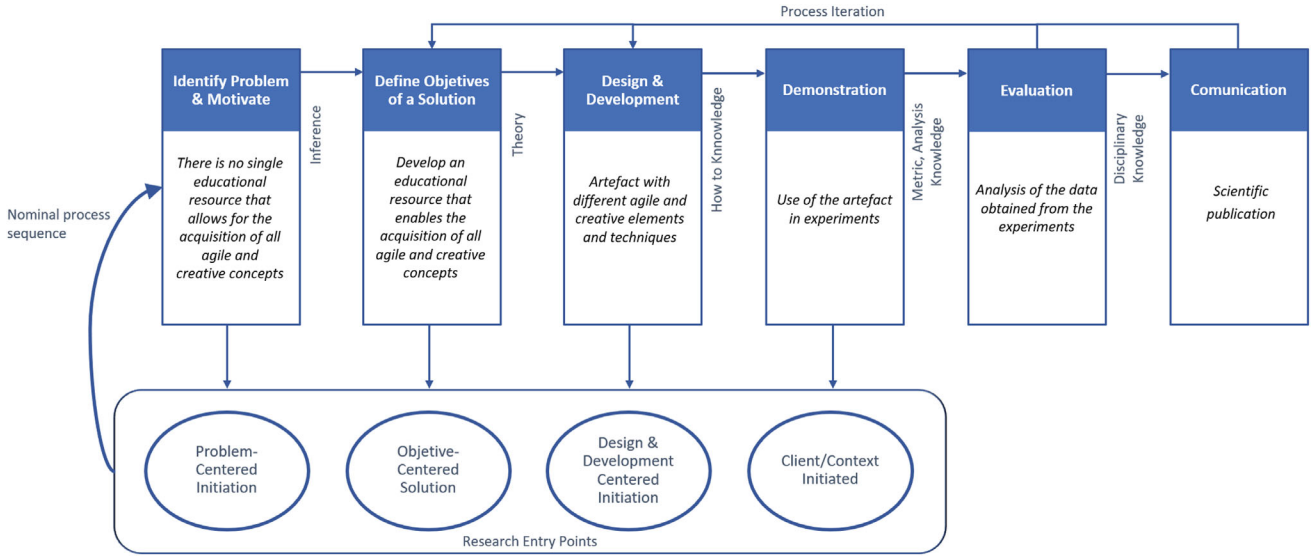

FIGURE 1 Summary of the design science research method applied to this work.[49]

to identify the most appropriate elements to achieve the proposed solution. Each of these iterations consisted of small tests to see if it was possible to achieve positive results with the educational resource being developed. These checks were limited to brief simulations of the educational resource between the authors of this research and other researchers with less experience in the field. As soon as improvements to the resource in the evaluation stage were identified, they were introduced in the design phase and checked whether they would allow the concepts of agility and creativity to be acquired in a better way. In this way, feedback was more frequent and the resource could be improved more quickly than by conducting more elaborate experiments, which would have slowed down the research considerably.

4. **Demonstration:** the designed educational resource had to be validated through experiments to check if the identified problem was solved, as the small tests carried out in the previous stage were not sufficient for scientific validation. Specifically, two experiments were conducted with computer science students to measure the effectiveness of the resource. These experiments had to be more complete and therefore of longer duration than the tests. In addition, these experiments had to reliably collect the necessary information on the increase in learning of these concepts with the educational resource. Therefore, any details that might interfere with validation had to be taken into account. For example, it was necessary to ensure that students were not near exams or other academic commitments to avoid distractions during the assessment.
5. **Evaluation:** the research process included an empirical evaluation. The data collected was used to adjust and improve the design and to ensure, to some extent, that the proposal could fulfil its educational purpose. To this end, the Intra-class Correlation Coefficient (ICC) was used to analyse the data collected through surveys. The iterative nature of the research method allowed us to carry out several iterations throughout the development and demonstration stages of the solution. Each of these iterations resulted in a more refined educational resource.
6. **Communication:** the final stage of the process was to produce a scientific communication to share the results of the research with the academic and professional community. This would allow the findings to be disseminated and contribute to knowledge in the field of education and software project management. In addition, this research provides a basis for other researchers to develop and extend this line of research.

The following section describes the design and development of the educational resource after all the iterations have been completed.

4 | DESCRIPTION OF THE EDUCATIONAL RESOURCE

DesignScrum, the proposal developed and presented in this work, is an agile educational resource powered with techniques and practices to foster creativity, which enables the acquisition of all these key concepts. This is a very novel aspect

as it simultaneously integrates the teaching of agility and creativity. It is aimed to be used as an educational resource in training centers and software companies, to teach or improve their agile processes such as computer auditing,[50] scientific software projects,[51] computer security,[52] and perhaps one day in quantum computing when it is more developed.[53] It is considered a serious game as it incorporates a number of game design elements and techniques, using them outside the gaming context and allowing companies to achieve business benefits.[18]

It is possible to compare software development with building a LEGO structure in terms of the Scrum and Design Thinking learning process, because in both cases projects are built on the basis of previous performances. This way, our proposal uses LEGO pieces in such a way that the student has to build a creative and original structure with the pieces and develop it in an iterative and incremental way.

DesignScrum consists of three iterations and includes all Scrum roles, events and artefacts, together with the following agile project management techniques: Kanban board, Burndown chart, Planning poker and Starfish retrospective for the LEGO construction project. We also added the role of the facilitator to coordinate the game.

To put creativity in place, we combined the Design Thinking method with Scrum by introducing the use of some Design Thinking techniques, such as Business model canvas, Stakeholders map and Service blueprint, as shown in Figure 2. Likewise, we introduced the Emphasise event at the beginning in order to carry out the Emphasise stage of Design Thinking.

As there are many similarities between the Scrum and Design Thinking processes, we joined the Creative sprint planning event from the Scrum Sprint to the Define and Ideate stage of Design Thinking. This was done to carry out all the functions of Sprint Planning and the Define and Ideate stage in one event. However, the rest of Scrum events have not been modified or grouped together with Design Thinking. We highlighted the Sprint retrospective event so as to promote communication and creativity when applying the Stafish technique.[54] All these inclusions were due to the need to include all the competencies described in Section 2.

Recommendations and materials needed to use this educational resource are:

1. **Time:** approximately 3 h and 50 min.
2. **Physical space:** clear space with a table and a board for each development team.
3. **Team size:** ideally we should have a facilitator, four teams of four or five students (development team), one Product Owner per team and one Scrum Master for every two teams.
4. **Stationery items:** colored sticky notes, pens, sheets of paper, small balls and poker cards that follow the Fibonacci sequence.
5. **LEGO pieces:** approximately 700 LEGO pieces per team.

During the game, participants must take on one of the following roles:

1. **Product owner:** this person is solely responsible for managing and prioritising the Product Backlog to obtain a product that complies with functionalities defined by the client when the last sprint is over.

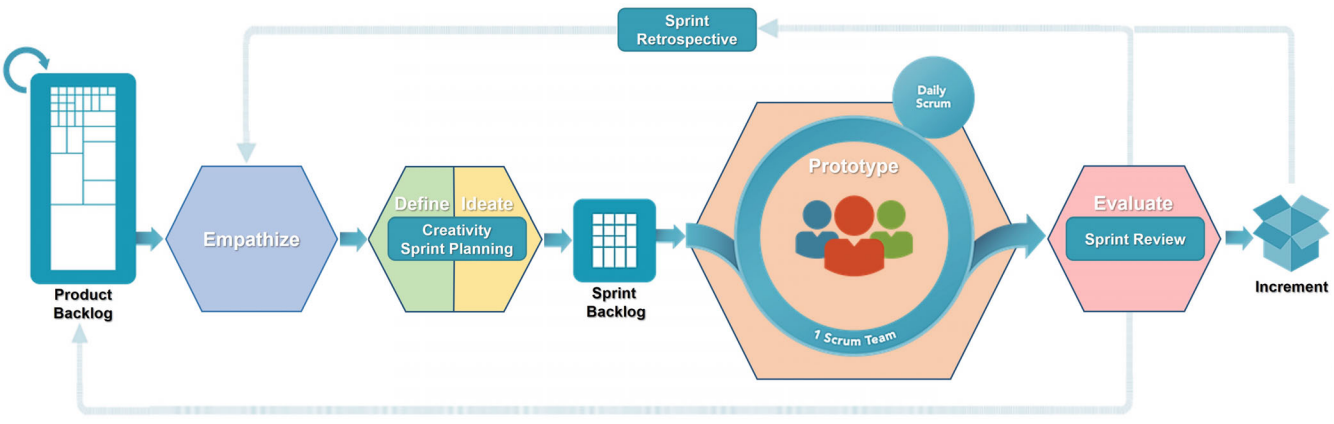

FIGURE 2 Summary of DesignScrum and its relation to scrum and design thinking.

2. **Scrum master:** this person facilitates Scrum events and leads the development team to become multi-functional and self-organised.
3. **Development team:** team of four or five students acting as developers (participants).
4. **Game facilitator:** the person responsible for coordinating the entire game and acting as the client.

To make it easier to identify the roles, different clothes are used. The person wearing a cap represents the Product Owner, a cowboy hat represents the Scrum Master, sunglasses represent the client and a scarf represents the game facilitator. These roles, with the exception of the development team, are represented by experts in agile and creativity methods.

The application of the educational resource comprises three different stages that are discussed in the following: before the game, game, and after the game. Figure 3 illustrates the whole process.

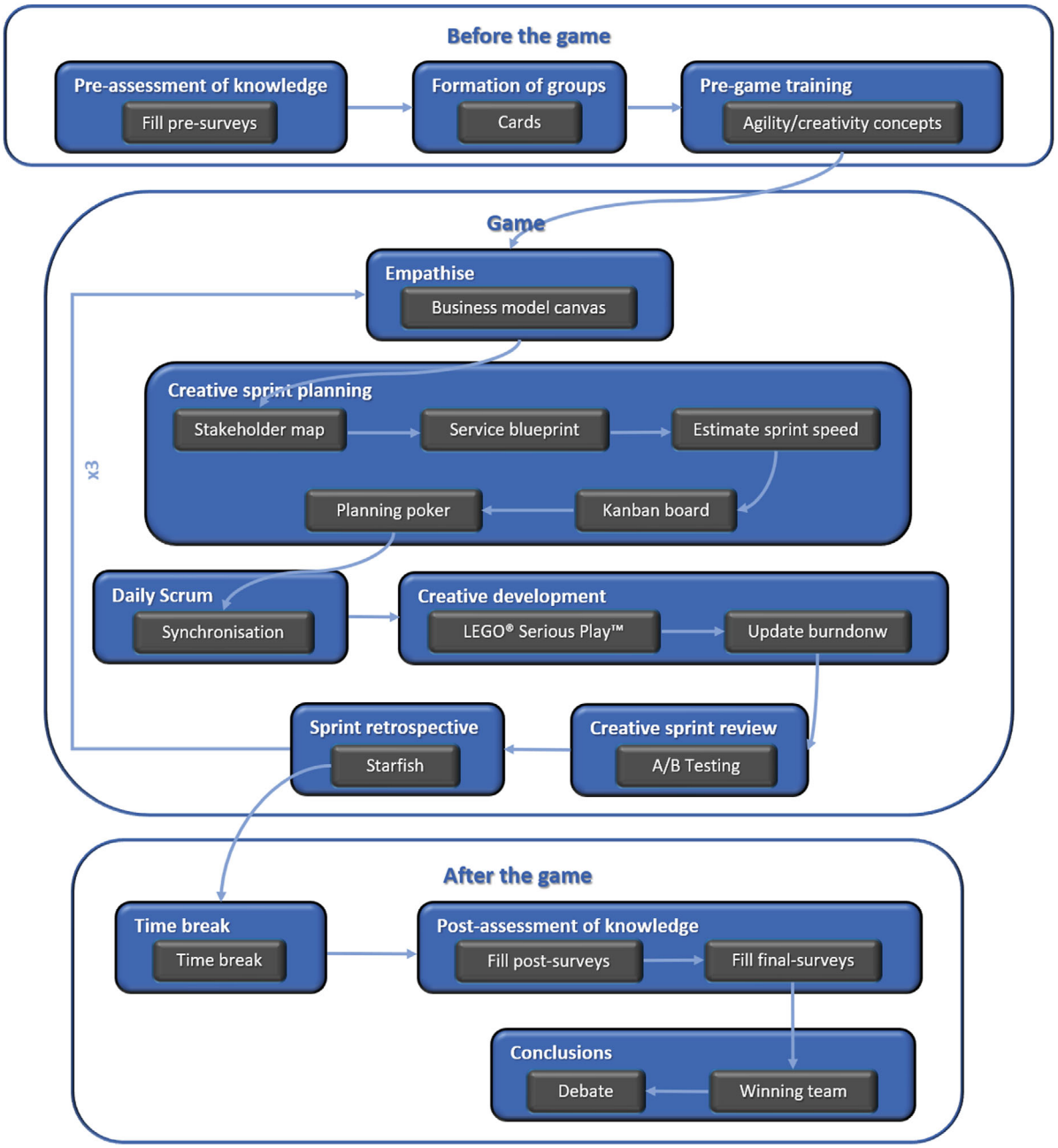

FIGURE 3 Before, during and after the game stages.

4.1 | Before the game

We will now explain the steps that must be taken before the game begins:

1. **Pre-assessment of knowledge:** before the start of the game, all participants fill in two surveys to assess their prior knowledge (5 min). The first survey focuses on agility, whereas the other is focused on creativity*.
2. **Formation of groups:** each participant is randomly given one card face down. The card has the number 1, 2, 3 or 4 written on it. This number represents the level of knowledge the participant has about Scrum and Design Thinking. Specifically, the number 4 represents the highest level of knowledge, while the number 1 represents the lowest level. Once all participants have a card, they turn it face up. They can exchange their card with other participants in order to obtain a card that accurately represents their level of knowledge, as a participant may initially receive a card that does not correspond to his or her level of knowledge. Participants do not necessarily have to exchange their cards, as they may have already been given a card that represents the appropriate level. Finally, each participant joins with others to form a group of four students. No group is enabled to have two participants with the same level and the level of knowledge of a participant corresponds to the number of the card that they have once the groups are formed. In this way, the teams should be more balanced than when they are formed randomly or when participants have complete freedom to form them. To make the game more fun and entertaining, participants cannot speak (or they can use just one vowel) when creating the groups. Thus, participants have to find alternative forms of non-verbal communication, such as gestures, signals or sounds. This limitation in communication fosters collaboration and encourages the exploration of new solutions to form the groups.
3. **Pre-game training:** in a 1-h session, participants are introduced to the key concepts of agility-based project management, the Scrum framework, creativity in software product development, and the Design Thinking framework. They are also given general information about the dynamics of the game and have the opportunity to ask questions. In addition, each participant is given a step-by-step guide to the different stages and techniques that make up the game.

4.2 | Game

This subsection is divided into two parts. First, Section 4.2.1 describes the different stages and techniques used in the game; next, Section 4.2.2 details the different steps that need to be taken to run the game.

4.2.1 | Game development

The game facilitator provides the development teams with the necessary materials to play the game: stationery items, LEGO pieces, and developed materials (defined at the beginning of this section). The user stories that make up the Product Backlog are represented by sticky notes filled in by the development team. To facilitate the game, it is recommended that a timer is attached to the projector so that participants can see how much time they have left. The game facilitator can also remind them after each event.

The game is played as follows:

Defining the creative sprint

1. **Empathise:** the development team put themselves in the position of any person whose job and activities the teachers believe they should be able to understand. The technique used is the Business model canvas. This technique promotes creativity by graphically describing nine areas which indicate how an organisation creates and delivers value.[17] In this way, the development team, with the help of the Product Owner, establishes a language and a common communication framework[55] to answer the following questions about the behaviour of the previously selected person:
   a. Who do we work for?
   b. What kind of product or service do we provide?
   c. How do we carry this out?
   d. Where do our revenues and costs come from?

   The development team needs to define the areas[17] for the first sprint and redefine them for subsequent sprints to reduce game time and increase efficiency by iterating on the areas defined in previous sprints.

It should be highlighted that all development team members must express their ideas and respect other suggestions even if they are not implemented.[17] To avoid distractions, all participants must switch off their mobile phones, computers or any other devices.

2. **Creative sprint planning:** the development team decides on the sprint approach by generating ideas through the Stakeholders map creative technique. This creative thinking technique consists of hypothetically becoming a consumer of the company which has been analysed in the previous event. In tis way, the team can identify problems that need to be solved, can focus on the ideas which are being generated and can find a solution to the problems. To design such solution, the development team use the Service Blueprint technique.[17] This should enable them to graphically visualise the flow of all relevant actors and resources involved in the product development.

   The development team then estimates the sprint velocity using the following formula[7,56] in which the different elements are explained below and in the Daily Scrum:

$$Expected\ sprint\ speed = \_X\ \ people\ \_X\ \ days\ \_LEGO\ \ points\ \ achieved = \_ \tag{1}$$

   The development team now uses Planning Poker to estimate the user stories which have been selected to form the Sprint Backlog and that will enable the sprint expectations to be met. On the other hand, they are recommended to establish a reference LEGO point unit of estimating the effort required to complete a user story, which could be joining two simple pieces together. Depending on the context, if estimations differ greatly, the Scrum Master could intervene to help the development team to come to an agreement. The development teams write down the different estimations for each user story on sticky notes, so that they can be easily checked later. It the effort required to complete any given user story is too large for one sprint, the team have to break down such user stories into smaller ones. The last step is for the team to create the Sprint Backlog which will be visualised on a Kanban board.
3. **Daily scrum:**after each (fake) day (one day is 5 min of sprint execution), the development team organises a meeting where all members must update the rest of the team on progress towards the sprint vision. To organise speaking time, developers have to hold a ball in their hands when it is their turn to speak. After the meetings, the development team updates the Progress chart (Burndown chart). The number of people represents the number of developers.
4. **Creative sprint review:** development teams show the Product Owner the increase they have achieved during the latest Sprint. The Product Owner determines which user stories have achieved "Done" status. User stories that do not comply with the requirements must go back to the Product Backlog so that, in the next Creative sprint planning, developers can decide whether to estimate them again or not and/or whether to introduce them in the Sprint Backlog or not. The development team needs to take a picture of the structure they have built in order to compare the product in two different sprints and analyse whether its performance in the sprint is aimed at the established vision in Creative sprint planning. This technique is known as A/B Testing.[57]
5. **Sprint retrospective:** the Scrum team inspects itself as a team using the Starfish technique, which consists of analysing the opportunities, risks and difficulties that have arisen during the sprint.

4.2.2 | Game steps

Considering this would be the first time these teams apply Scrum, sprints with different time lengths are proposed for an appropriate experience with the game, even though students should be aware of the need to establish a consistent time-box for different sprints. We explain the different sprints below:

The first sprint lasts 53 min and consists of the events:

1. **Emphasise:** 7 min.
2. **Creative sprint planning:** 20 min.
3. **Daily scrum:** 2 min.
4. **Development:** 5 min.
5. **Daily scrum:** 2 min.
6. **Development:** 10 min.
7. **Creative sprint review:** 2 min.
8. **Sprint retrospective:** 5 min.

It should be noted that, to avoid exceeding the necessary time for the game, Daily Scrum is only applied on the first two occasions, and the number of times the event Emphasise should be applied has been reduced.

For the second sprint, we consider that the students have learnt the dynamics of the game and that it is therefore not necessary to apply the Daily Scrum as such, but simply to reflect the information regarding the work done on the Progress chart. In addition, the following sprints introduce some special situations to be performed, in order to introduce students to some of the contingencies of a real software project.

The second sprint lasts 27 min and consists of the events:

1. **Emphasise:** 2 min.
2. **Creative sprint planning:** 8 min.
3. **Development:** 15 min.
4. **Creative sprint review:** 2 min.
   Special situation 1: the Product Owner decides to add a new functionality, which is a top priority. This makes the Scrum team receive a user story that is independent from the pieces which are being built, meaning that it must be estimated and added to the Product backlog and to the Sprint backlog in the next iteration. For example, this may be the construction of a house block.
5. **Sprint retrospective:** 3 min.

The third sprint lasts 30 min and consists of the events:

1. **Emphasise:** 2 min.
   Special situation 2: before the next Creative sprint planning, each development team changes projects, and two members of each team are exchanged for two members of a different team.
2. **Creative sprint planning:** 8 min.
3. **Development:** 15 min.
4. **Creative sprint review:** 2 min.
5. **Sprint retrospective:** 3 min.

4.3 | After the game

After the third sprint is over, participants are given a 5-min time break. Afterwards, they carry out the following stages:

1. **Post-assessment of knowledge:** 15 min during which each participant anonymously fills out three surveys about the game. The first two assess their knowledge after the game and are exactly the same as the surveys they took before the game. As these surveys are identical to the previous ones, it enables comparisons to be made in order to understand participants' learning. The third survey is aimed at obtaining the participants final opinion about the game.
2. **Conclusions:** the team that adds the most creativity to the product is the winning team. Based on the paper by P. Ralph et al.,[58] each team has 5 min to fill in a winner's table scoring different creative aspects of the product. This table* takes into account the team's performance, the performance of the other teams and the expert assessment to ensure that the winner is not chosen solely on the basis of the final result of the product.

A 20-min group debate then takes place between all participants so as to obtain conclusions regarding how the game went and how it could be improved. Some of the questions might be: what new knowledge did you gain? what technical difficulties did you encounter? what was the biggest obstacle your team faced? or what is your general opinion of the game?

5 | ASSESSMENT OF THE EDUCATIONAL RESOURCE

In the field of software engineering, as in many other disciplines, empirical methods are required in order to validate the proposed theories, to assess their functionality, to identify their possible limitations and to identify aspects to be improved.[59] The four most commonly used empirical methods are experiments, case studies, surveys and post-mortem

analysis.[60] Specifically, experiments and surveys have been used to obtain data to draw conclusions from the educational resource developed.

In this section, we therefore address the assessment of the educational resource presented in this paper. We believed it was appropriate to carry out its preliminary validation throughout a pilot empirical study with computer science students. Such study allowed us to assess whether the game proposed in this paper could enable students to learn key concepts regarding agility and creativity in greater depth than existing games, and that introducing creativity is not detrimental to agility learning. Despite many agile games aimed at teaching already existing (like SCRUMIA[31] or Scrumify[40]), none of them are powered with creativity and therefore do not enable a learning process for disruptive product development.

To prevent any distortions related to students skills' when building LEGO blocks or created by groups that may not be totally balanced in terms of previous knowledge, this kind of assessment must be done with large-scale experiments or by forming more homogeneous groups. Including a large number of participants was beyond our reach, given that the target of our proposal was a small number of users (24 students in their second year of Higher-Grade Professional Training in Networked Computer Systems Management). This is, in fact, a common problem in evidence-based computer science studies,[61] as shown in previous papers including students-based assessments.[62,63] As mentioned before and in order to overcome these problems, we created homogeneous groups before the game to prevent their previous knowledge and skills from influencing the results.

We will now explain the main results of the two experiments.

For the first experiment, a group of students played DesignScrum. As explained before, pre-surveys were used to assess their previous knowledge on agile and creativity. They filled out the very same surveys after the game in order to assess their improvement, as well as obtaining their opinions about the game. Note that the surveys used in the experiments were specifically designed for this game, taking into consideration the recommendations described in the literature.[64,65]

The winner's table enabled us to determine the winners based on team performance, expert assessment and direct observation of how the experiments were executed. In other words, the experiment focused on assessing participants' knowledge before and after the game, while the winner's table was only included as a gamification element.

For the second experiment, a group of different students from the same class were given the necessary elements to repeat the game that was played in experiment one, but there was no component of creativity. This way, we could find out whether the creativity component of DesignScrum influenced the agile knowledge acquired by participants during the game. For this reason, these participants did not fill out the surveys related to creativity.

We limited both experiments to focus mainly on Scrum because it is the reference framework for agile work. We did not combine Scrum with other frameworks in order to reduce the complexity of the assessments, as most participants had some knowledge regarding the framework, even if they did not fully understand all the different components and elements.

Before conducting the evaluation, we needed to know and collect with the experiments what kind of data was needed. Once it was determined that the data needed to be primarily numerical to compare with each other and some descriptive, we decided to use the following sources of information in the data collection process:

1. Surveys filled out by participants.
2. Expert assessment.
3. Direct observation of the execution of experiments.

The following subsections describe the different features and elements used in the experiments.

5.1 | Planning-experiments 1 and 2

Each experiment was carried out following the recommendations and guidelines of Reference 66. The main elements and components that influenced the planning of the experiments are detailed below:

1. The number of experimental subjects in both studies were 12 students in their second year of Higher-Grade Professional Training in Networked Computer Systems Management at the Professional Training Institute, in Julián Camarillo, Madrid.
2. The materials used were LEGO pieces in a great variety of shapes and colors. We also provided stationery items and Poker estimation packs of cards following the Fibonacci sequence. In addition, we provided the materials to represent

the Product Backlog, the Sprint Backlog (Kanban board), the Burndown chart, the Business model canvas, the Service blueprint and the surveys.
3. Finally, we conducted two quantitative analyses: one focused on identifying participants' prior knowledge and the other on their knowledge after the game.

We will now explain the three components of each experiment.

5.1.1 | Subjects-experiments 1 and 2

As previously mentioned, the subjects of each experiment were 12 computer science students (24 was the total number of students enrolled in the year the proposal was tested) in their second year of Higher-Grade Professional Training in Networked Computer Systems Management at the Professional Training Institute, in Julián Camarillo, Madrid. The small number of participants taking part was exclusively due to the number of people available for this activity.

Due to limitations to participant homogeneity because of the number of participants who took part in their experiment, their formal academic training at Universities or Professional Training Centers in different areas of knowledge, and their skills when building LEGO blocks, it was necessary to divide participants into different groups using the technique described in Section 4.1, which is quite common in this kind of experiment.

Requirements to take part in the experiment were simply to be enrolled in the subject "Network and Internet services" where the experiment took place and to be willing to enhance their training as a participant, since the experiment was part of a voluntary activity. In addition, knowledge of agile management or creativity in the context of software development was not a requirement, as this knowledge is not taught in the Professional Training degree and none of the participants had previously acquired it.

5.1.2 | Materials-experiments 1 and 2

The following materials were used in the first experiment:

1. **Physical space:** of an academic classroom with enough space where to carry out the game.
2. **Glass screens:** separating the different teams to simulate a real working environment where communication is not direct or immediate.
3. **Pre-survey:** on agile project management and another one on creativity to assess their knowledge on these topics before the game.
4. **Cards:** each participant was given a single card to create homogeneous groups in terms of prior knowledge of agility, creativity or LEGO building skills.
5. **Slides:** introducing the key concepts of agile project management and creativity in the context of software development.
6. **Winner's table:** given to each group at the end of the game and contains eight criteria, rated from 1 to 10, to find out which group has introduced the most creativity.
7. **Post-surveys:** used to draw conclusions about the participants' learning and to assess the educational resource developed.

The material included in the game for the second experiment was identical to that used in the first experiment. Except for the pre-surveys and post-surveys that included the concepts of creativity, and the omission of the corresponding theoretical explanation before the game.

5.1.3 | Design of experiments

The following experiments were designed:

Experiment 1-DesignScrum, agile and creativity fostering educational resource: in Section 4, we included a detailed explanation of the different elements and components that conform the agile educational resource powered with

creativity presented in this work. The aim was for all participants to understand the key concepts of Scrum and Design Thinking and to extend their knowledge through the use of several complementary techniques.

To verify that the use of this resource would result in participants acquiring a greater number of agile and creative concepts than those acquired by means of existing proposals and to obtain data which could help to identify possible advantages or limitations of this proposal, we carried out a first experiment.

This experiment was carried out in the context of a practical assessed class of a subject which is part of a Higher Degree in a Spanish Professional Training Innovation Center. We followed certain guidelines which established the need to determine the approach, materials used, method and result analysis.[67]

We must take into account that, in this experiment, we jointly used the Scrum and Design Thinking concepts within software development. However, it should be highlighted that there are considerable differences. The aim of Scrum is to apply an iterative and incremental approach to optimise predictability and risk control in software projects,[4] whereas Design Thinking focuses on generating creative and innovative solutions when developing software products through stages and techniques which foster creative thought.[15,68]

Despite these differences, jointly using these concepts in the experiment was aimed at assessing whether all the key agile and creative concepts were acquired simultaneously within a single-educational resource.

Experiment 2-DesignScrum, agile-only educational resource: to assess whether introducing creativity in DesignScrum does not reduce the agile knowledge acquired by participants, we carried out a different experiment with students from the same class who had not participated in the first experiment. They were therefore 12 students in their second year of Higher-Grade Professional Training in Networked Computer Systems Management at a Professional Training Institute.

The experiment consisted of the students completing the proposal shown in Figure 3, but taking out the steps related with creativity enhacement. In other words, surveys related to creativity, the empathise stage, the Business model canvas, the Stakeholders map, the Service blueprint and the A/B Testing were not introduced in this game.

5.2 | Results and analysis

This section analyses the results obtained in the experiments carried out.

5.2.1 | Results and analysis-experiment 1

As previously mentioned, one of the first steps in this experiment was to ask participants a series of questions to determine their prior knowledge of agility and creativity in the context of software development. We also assessed whether they were able to apply this knowledge in a real environment before playing the game.

Table 2 summarizes the answers provided by participants to each of the questions asked in the different surveys. These surveys were divided into three subcomponents "I understand the concepts/methods", "I understand how the concepts/methods work in practice" and "I am capable of applying the concepts/methods to a real setting", and thirteen and ten concepts/techniques related respectively to agile and creativity. Participants could rate then their knowledge about each topic as 1 (very low), 2 (low), 3 (moderate), 4 (high) or 5 (very high). This way, participants were able to assign intermediate values rather than just binary scores. This scale was based on the guidelines of Fowler et al. allowed us to draw more accurate conclusions about the game, as the scale has enough possible values and is not large enough to overwhelm participants.[65]

The data in Table 2 shows the arithmetic averages of the answers provided by all the participants for each question included in the pre-surveys and post-surveys. These data confirm that most participants did not possessed basic knowledge on agile project management. The data show that participant previous knowledge was homogeneous.

Regarding creativity knowledge, the results reveal little experience in creative product development. In particular, the concepts Define, Ideate and LEGO® Serious Play™ stood out above the rest.

Once the game had finished, participants filled in three surveys. The first and second were identical to those filled before the game. We used them to obtain conclusions regarding how much participants had learnt, and therefore validate the ability of the game as an educational resource. Indeed, an analysis of the pre-surveys and post-surveys showed a large improvement in the levels of knowledge of all concepts/techniques.

The third survey, divided into three categories, was used to assess the quality of the game in terms of motivation, user experience and learning, in order to determine whether the learning process negatively affected participants' well-being

TABLE 2 Results of the pre-surveys and post-surveys.

	Experiment 1		Experiment 2	
	Pre-survey	**Post-survey**	**Pre-survey**	**Post-survey**
Agility				
Sprint planning	1.81	4.08	1.81	4.00
Daily Scrum	1.89	4.14	1.97	3.94
Sprint review	1.72	4.19	1.72	3.97
Sprint retrospective	1.72	4.14	1.72	4.03
Self-organised	1.78	4.17	1.69	4.19
Multifunctional	1.69	3.97	1.81	3.94
Product Backlog	1.64	4.14	1.61	4.11
Sprint Backlog	1.50	3.94	1.50	3.97
Increment	1.53	4.14	1.53	4.19
Effort estimation	1.86	3.83	1.81	4.06
Burndown	1.39	3.86	1.36	4.00
Risk management (team changes, etc.)	1.64	4.03	1.44	4.06
Creativity				
Emphasise	1.89	3.97	—	—
Define	2.03	4.19	—	—
Ideate	1.97	4.36	—	—
Prototype	1.86	4.33	—	—
Evaluate	1.89	4.36	—	—
Business model canvas	1.61	4.17	—	—
Stakeholders map	1.67	4.11	—	—
Service blueprint	1.50	4.17	—	—
LEGO® Serious Play™	2.03	4.47	—	—
A/B Testing	1.53	4.11	—	—

during the game. These categories consisted of multiple choice questions representing an emotional and cognitive task of the game. The tasks were in turn associated with one of the following areas: Attention (A), Relevance (R), Confidence (C), Satisfaction (S), Immersion (I), Social Interaction (SI), Challenge (CH), Entertainment (EN), Competitiveness (CO), Short-term learning (STL) and Long-term learning (LTL).

The results (on average) of this survey are shown in Table 3. We can observe a general satisfaction with the game, especially regarding its attractiveness, the variety of components it comprises and the recreational aspect, as well as the participants' involvement during the game and their interaction with other participants.

In addition, the survey included a free-text question for students to provide any suggestions for the game. The most common answer was to increase the time length of the game. However, we believe that this would cause mental fatigue in participants and reduce their learning capacity.

From the results obtained after processing the general evaluations of the participants, an analysis of variance was performed. This analysis made it possible, among other things, to obtain the mean rating for each of the 27 questions asked in the general survey, as well as to identify the standard deviation (SD), which enabled us to know the dispersion of the data with respect to the mean, as shown in Table 4.

These results show that DesignScrum obtained very good results in the three categories which were assessed. All three reach an average rating above 4.30 out of 5, while the standard deviation remained low. We can therefore state that all participants had very similar opinions after playing the game and they were quite positive about their experience.

TABLE 3 Results from the final surveys.

	Area	Experiment 1	Experiment 2
Motivation			
1. The game is attractive to play	A	4.58	4.42
2. There was something interesting which caught my attention at the beginning of the game	A	4.25	4.17
3. Variety (form, content or activities) helped me kep focused	A	4.58	4.25
4. Contents of the game are relevant to my interests	R	4.50	4.33
5. The way the game works adapts to my way of learning	R	4.25	4.17
6. Contents of the game are linked to knowledge I already had	R	4.08	4.17
7. It was easy to understand the game and use it as study material	C	4.17	4.75
8. While playing, I felt sure I was learning	C	4.17	4.17
9. I am satisfied because I know I will get the chance to put what I learnt during the game into practice	S	4.33	4.08
10. I made progress in the game thanks to my personal efforts	S	4.33	4.08
User experience			
11. I forgot about my personal problems; I was totally focused on the game	I	4.58	4.42
12. Time flew by while I played; the game finished quickly	I	4.58	4.402
13. I was more into the game tan into real life, forgetting my surroundings	I	4.42	4.42
14. I was able to interact with other participants during the game	SI	4.58	4.42
15. I had fun with other participants	SI	4.42	4.25
16. The game promotes cooperation and/or competitivity between players	SI	4.42	4.25
17. The game was a challenge because tasks were neither too easy nor too difficult	CH	4.42	4.33
18. The game progresses at an appropriate pace and does not become boring: it offers new obstacles, situations or varied tasks	CH	4.08	4.17
19. I had fun with the game	EN	4.50	4.25
20. When the game ended, I was sad it was over	EN	4.25	3.83
21. I would recommend this game to my friends	EN	4.25	4.17
22. I achieved the objectives of the game applying my knowledge	CO	4.42	4.33
23. I had positive feelings about the efficiency of the game	CO	4.25	4.33
24. I would like to play this game again	EN	4.33	4.08
Learning			
25. How much do you think this game contributed to your learning process during this course?	STL	4.42	4.25
26. How efficient was the game for your learning process, compared to other activities in this course?	STL	4.33	4.17
27. Do you believe this experience will help you in your future professional performance?	LTL	4.50	4.17

TABLE 4 Statistical analysis of the final survey.

	Experiment 1		Experiment 2	
	Avg	SD	Avg	SD
Motivation	4.32	0.177	4.25	0.202
User experience	4.39	0.147	4.24	0.158
Learning	4.41	0.083	4.19	0.048

Given that the assessment was carried out by means of quantitative surveys, it was necessary to ascertain whether they were solid from a statistical point of view. To do this, we calculated the ICC to assess the reliability of our analysis. We compared the variance of one participant's rating to the total variance of all participants. The basic concept behind ICC was originally introduced in Reference 69 as a special formulation of Pearson's R when measures and distributional variance are equal.

The guidelines given in Reference 70 were followed to calculate the ICC estimates and their confidence intervals of 95% using the variance analysis procedure (ANOVA) of MS Excel Analysis ToolPak (Microsoft Corporation, Redmond, WA), based on a single evaluation/measurement absolute, two-lane random effects model. To do this, it was necessary to know beforehand that the data followed a normal distribution using the Gaussian bell curve.[71] In addition, the selection and calculation of the ICC, the proposed guidelines of Reference 70 were considered regarding the selection, type and definition of the model according to the characteristics of each experiment.

When the analysis of variance (ANOVA) on the answers to the quantitative questions was finished, we obtained the necessary values to calculate the ICC for each survey, as shown in Table 5. Values of this coefficient range from 0 to 1, with 0 indicating a complete lack of coherence, and 1 indicating complete consistency and coherence in the results. Values below 0.4 usually indicate that the results are not very reliable, values between 0.4 and 0.75 indicate a high reliability, and values above 0.75 indicate excellent coherence.[72] The values obtained for these surveys ranged from 0.7654 to 0.8238, thus indicating that participants' answers are highly reliable.

These ICC values enable us to reject the theory that the answers to the surveys could have been given randomly. The low variance in the ratings can probably be explained by the fact that the participants had very similar profiles and prior knowledge. It is also important to note that the surveys were anonymous and that playing the game influenced the participants' answers, making it unlikely that they would have given random answers.

Moreover, the table which was filled in to decide the winning group enabled us to check whether the LEGO piece which was built was creative. To determine the dispersion of the data, we obtained the standard deviation of creativity during construction, and we analysed the quartiles of this data. We then obtained the interquartile range (IQR): the distance between the first quartile (Q1) and the third quartile (Q3). In this regard, it should be highlighted that the IQRs are rather high, which indicates no differences in creativity between some groups and others. This data is summarised in Table 6.

In the table of winning criteria, there was a question about the number of pieces introduced into the LEGO block structure. This number was divided by 5 to make it less important in determining the winner. The analysis which was carried out and the expert opinion coincided when choosing the most creative group, as shown by the number of different pieces and colors, the number of ideas generated and the number of added functions. Obviously, this was the team which achieved the greatest number of points in most criteria.

Finally, the participants in the group discussion were asked if, after conducting the experiment, they believed it was better for their learning process to teach agile and creativity methods through gamification or employing traditional teaching methods. Eight participants preferred the game, whereas four participants did not have a clear opinion.

5.2.2 | Results and analysis-experiment 2

As mentioned before, experiment 2 was conducted in exactly the same way as experiment 1, except that creativity was deliberately not included. The aim was to find out if creativity would hamper agile learning. In the following we discuss the main results, which are shown in lower part of Table 2.

For the pre-surveys and post-surveys on agility, the prior knowledge scores for the second experiment were 774 and 1888 points compared to 784 and 1889 points for the first experiment. The total variance for one concept or technique compared to another was −4 to +7 in the pre-survey and −8 to +8 in the post-survey. The negative variation of some concepts in experiment 1 with respect to experiment 2 shows that these concepts were acquired to the same extent, because this difference is very small. We can therefore conclude that both groups of participants had very similar knowledge before the game and that the introduction of creativity did not hinder the learning process of agile concepts.

The results of the final survey reflected lower values for the teaching category in this experiment. This was probably due to lower levels of motivation of the students, who were told exactly what product they had to develop, with less opportunity to be creative. However, participants rated their confidence in the learning process with the same average score.

TABLE 5 Summary of the values of the intraclass correlation coefficient.

Validation source	SS	df	MS	F	P value	Critical F
Experiment 1						
Agility pre-survey						
Rows	405.6068376	11	36.873348873	181.91546454	1.0516E − 151	1.811576212
Columns	12.2991453	38	0.323661718	1.59679209	0.015884888	1.433878957
Error	84.7264957	418	0.202694966	—	—	—
Total	502.6324786	467	—	—	—	—
					ICC	*0.8155*
Creativity pre-survey						
Rows	313.8305556	11	28.530050505	114.59518730	9.5015E − 104	1.818727563
Columns	18.9472222	29	0.653352490	2.62428736	2.16327E − 05	1.503168296
Error	79.4194444	319	0.248963776	—	—	—
Total	412.1972222	359	—	—	—	—
					ICC	*0.7693*
Agility post-survey						
Rows	260.2286325	11	23.657148407	148.28279398	1.0292E − 136	1.811576212
Columns	15.465812	38	0.406995052	2.55104133	3.22206E − 06	1.433878957
Error	66.6880342	418	0.159540752	—	—	—
Total	342.3824786	467	—	—	—	—
					ICC	0.7698
Creativity post-survey			—	—	—	—
Rows	240.208333333	11	21.837121212	107.10121717	4.6069E − 100	1.818727563
Columns	9.525	29	0.328448276	1.61089045	0.026858360	1.503168296
Error	65.041666667	0.203892372		—	—	—
Total	314.775	359	—	—	—	—
			—	—	—	—
					ICC	0.7709
Final survey			—	—	—	—
Rows	191.1111111	11	17.373737374	97.32317737	7.58595E − 90	1.822217797
Columns	7.3888889	26	0.284188034	1.59194777	0.036885095	1.534448319
Error	51.0555556	286	0.178515929	—	—	—
Total	249.5555556	323	—	—	—	—
					ICC	*0.7727*
Experiment 2						
Agility pre-survey						
Rows	448.4358974	11	40.766899767	204.73875539	1.2503E − 160	1.811576212
Columns	18.2564103	38	0.480431849	2.41281577	1.24969E − 05	1.433878957
Error	83.2307692	418	0.199116673	—	—	—
Total	549.9230769	467	—	—	—	—
					ICC	*0.8238*

(Continues)

TABLE 5 (Continued)

Validation source	SS	df	MS	F	P value	Critical F
Agility post-survey						
Rows	275.8119658	11	25.073815074	132.35402051	1.2503E − 160	1.811576212
Columns	10.4529915	38	0.275078722	1.45202375	1.24969E − 05	1.433878957
Error	79.1880342	418	0.189445058	—	—	—
Total	365.4529915	467	—	—	—	—
					ICC	*0.7645*
Final survey						
Rows	235.2932099	11	21.390291807	98.74016140	1.50097E − 90	1.822217797
Columns	8.4876543	26	0.326448243	1.50692438	0.057636300	1.534448319
Error	61.9567901	286	0.216632133	—	—	—
Total	305.7376543	323	—	—	—	—
					ICC	*0.7765*

TABLE 6 Summary of the winning criteria.

	Experiment 1			Experiment 2		
	Avg	SD	IQR	Avg	SD	IQR
Winning criteria						
Number of pieces used during the game (divided by 5)	41.33	7.57	14	35.33	6.11	12
Number of pieces used during the game in comparison with the team which used the most (divided by 5)	−8.67	7.57	14	−6.67	6.11	12
Number of different colors used during the game	12	2	4	8	1	2
Number of different colors used during the game in comparison with the team which used the most	−2	2	4	1	1	2
Number of product ideas generated	4.67	3.79	7	3.2	3.23	6
Number of functions added to the product	7.33	2.52	5	4.67	1.15	2
Relation between the number of functionalities and the number of unfinished functionalities	6.33	1.53	3	4	1	2
Expert opinion (over 10)	9.33	0.58	1	9.33	0.58	1
Total points	70.33	19.14	37	55.7	10.97	21

Regarding the statistical analysis of the data obtained from the second experiment through the different surveys, we obtained values very similar to those of the first experiment. For example, the average motivation score was 4.32 and 4.25 points in the first and second experiments, respectively, as shown in Table 4. It can therefore be concluded that the participants did not fill in the surveys randomly and that the values are solid.

The table for the winning teams (right-hand side of Table 6) shows that the average score for these groups is 20% lower than in the first experiment. This score proves somehow that the products developed in the first experiment were more creative than the products from the second one, despite the fact that both groups were instructed to build exactly the same LEGO structure.

Finally, participants also indicated in the free-text question for suggestions that they would have preferred to learn project management and creativity through games rather than through traditional methods. In particular, seven participants stated that they preferred games, four did not have clear opinion and one stated he/she would have preferred traditional methods. Participants also indicated that they needed more time during the game.

5.3 | Discussion

After describing the experiments and results, we can discuss the questions raised in the above sections. To do this, we have based our research on the analysis of the data gathered from the surveys and from our direct observations.

On the one hand, the first experiment enabled us to answer the first five questions posed, as shown below:

1. **AQ-1-1.** What are the key concepts of agility and creativity that can be learnt in a single game?
   The educational resource developed enables participants to learn all the key agile and creativity concepts. According to the collected data, the concepts that were most difficult for the students to assimilate were Estimate effort and Kanban board, which were scored 1.86 and 1.61 points before the game, and 3.83 (both) after the game. However, the extent to which the concept is understood may vary from participant to participant.
2. **AQ-1-2.** How did the players perceive the effect of risk management on software projects?
   Although our proposal is educational and participants feel that their performance affects their academic studies, the game enables them to experience risk management by overestimating and underestimating tasks, changing requirements and altering team composition. Specifically, participants' pre-survey and post-survey show that they perceived their knowledge on risk management to have improved drastically (from 1.64 to 4.03 points).
3. **AQ-1-3.** When participants were playing the game, what elements kept them motivated throughout the experience?
   The surveys show that the game kept participants motivated. More specifically, they rated their motivation level at 4.08 points. From our experience, this was mainly due to the fact that they felt they were creatively free to design the product they want and they were instructed to do so while playing. At the end of the day, they found their selves learning in a very enjoyable context and this was extremely decisive to keep them motivated through the game.
4. **AQ-1-4.** What aspects contributed to the participants' enjoyment of the game experience?
   The teaching of agile and creativity methods was enjoyable for the participants mainly because they temporarily forgot their personal issues, did not notice the passage of time and were able to interact with other participants. This information, like the previous question, was taken from the final surveys, which showed an average score of 4.58 out of 5 for each of these three user experience questions.
5. **AQ-1-5.** How did the participants feel about learning through play compared to traditional learning methods?
   Learning through gamification was largely appreciated by participants because they learnt, but they also had fun and felt that the concepts they had acquired would help them in their professional careers. This category of the final survey received the highest score among the three categories of the survey. Specifically, participants rated at 4.5 their confidence on the gaming experience contributing to their future professional performance.

On the other hand, the second experiment enabled us to find answers to our last two questions:

1. **AQ-2-1.** How does creativity affect the depth of learning of key agile concepts?
   The introduction of creativity did not hinder the learning process of key agile concepts. The agility and creativity post-surveys show that participants acquired all agile concepts and techniques regardless of whether the experiment included creativity. As a matter of fact, the learning of the Effort estimation concept showed the biggest difference between the two groups of students, and it only reaches a variance of 0.23 out of 5 points.
2. **AQ-2-2.** What influence does creativity have on participants' attraction to the game?
   All categories of the game without creativity were rated lower than in the first experiment. One participant even said that he would not like to play again because they did not feel comfortable with this teaching method. Despite this, none of the subcomponents received significantly lower ratings than the game with creativity, with the ease of understanding the game being the worst rated question in the experiment that integrated creativity, with a variation of 0.58 out of 5 points.

These experiments enabled us to get satisfactory answers to all our questions and to identify some of the main limitations of DesignScrum, which gave us some working guidelines for the future, that will be discussed in the next subsection.

5.4 | Current limitations and future work

The limitations and areas for future work identified in this assessment are described below:

1. **Design of this research:** as the only way to conduct the study was in an experimental manner. However, the instruments used to assess the level of agility and creativity before and after the game have not been validated, because we would have needed a very large number of participants to test in different experiments which instruments gave the best results. Data extraction through direct observation was limited to researchers guiding and analysing the course of the game, without a predefined format supported by the literature.
2. **Participant conditions:** such as learning ability, mental fatigue and different skills when building LEGO structures could cast doubt on the results. Therefore, we reduced any possible mental fatigue or differences in learning ability by not allowing students to participate in more than one experiment.
3. **Increase the number and variety of experiments:** would allow the conclusions of this small study to be generalised. This could be achieved with students from different schools, classes and applied in companies. On the other hand, the increase in teleworking due to the COVID-19 pandemic has changed the way of working and communicating in work environments. Therefore, we cannot state that this training, aimed at face-to-face work environments, can be applied to telework until a validation is performed.
4. **Inclusion of other parameters in the surveys:** would allow to know if they influence the analysis of the evaluation results. These parameters, such as the participant's confidence in playing correctly, were not included because they would increase the complexity of the game by adding new complementary techniques that would encourage these parameters.
5. **Objectively evaluate the assessment:** given that the participants indicated their own perceptions without any examination or objective test. Their profile is that of final year undergraduate students, so their opinion should be quite reliable.

Despite the limitations mentioned above and the difficulties found in measuring learning efficiency,[73] the results obtained could also be considered reliable because there is some evidence that they are reliable, for example, the participants' satisfaction and experience with the game.[74] To reduce these limitations, the surveys used have been analysed and assessed to guarantee their accuracy and to assist future researchers who may wish to use them in their case studies.

5.5 | Threats to validity

We will now explain some of the main threats to the validity of this study, following the categorisation indicated in Reference 67 and the order proposed in Reference 75, which can be understood as a progress from the details of the experiment to the more general overview.

Construct validity refers to the relation between the theoretical aspects taken into account for the experiment and the observations which have been obtained from it. In fact, the first version of the document included just one experiment, used to compare DesignScrum with other agile teaching resources in the context of software development. However, we realised that the experiment could not be used to obtain conclusions as to whether agile concepts were included in DesignScrum.

As a consequence, we carried out a second experiment with students from the same class. The specific aim was to prove that DesignScrum's creativity did not limit the number of agile concepts which could be learnt and that it could even improve the amount of knowledge acquired.

For that matter, the approach of our second experiment could, in a way, actually constitute a threat to construct validity. Our aim was to prove that the theory of agile principles could be correctly applied, enabling a supporting work framework which would be used to assess the different elements and components that were introduced, and that would also help select those elements and components when choosing which to include in the educational resource. A singles experiment cannot ultimately be used to prove all the ramifications of a specific idea.

Internal validity is related to causality, in other words, to the certainty that the treatment of the data has led to the result obtained. This is traditionally one of the greatest threats to validity. The first experiment consisted of the freedom to build a LEGO structure simulating the different situations that are common in a real project, which undoubtedly implies that the participants accumulated some experience as the experiment progressed.

To mitigate this learning effect, participants were provided with a detailed step-by-step guide to the different stages and techniques that make up DesignScrum, while lacking help from the game facilitator and the rest of the participants. This guide was, in a way, an attempt to compensate for the participants' experience in software project management based on agility, creativity and the ability to build a LEGO structure.

The experiments separated the participants into different groups, as we felt that the experience of the students involved in the first experiment would eliminate the homogeneity of the groups in the second experiment if they participated in both experiments. However, most of the students had no prior experience with software project management, creativity, or concepts related to the experiment.

Prior training on these concepts was provided to ensure that all participants shared a basic understanding of the main concepts that were necessary for the proper execution of the game. In addition, all students who participated in the second experiment belonged to the same class as the participants in the first experiment and, in both cases, lacked these types of concepts.

In fact, students who were involved in other studies related to computer science in the same professional training center were excluded from the experiment to prevent participants from already being familiar with agility and creativity.

A simple educational resource was chosen for both experiments, and this could also be considered a threat to internal validity. As mentioned in this paper, we applied complementary techniques for the development of DesignScrum. We could have used different techniques, but our goal was to use as few as possible in order to reduce accidental complexity without reducing the quantity or quality of concepts acquired. This also prevented participants from becoming excessively tired, given that these concepts are not learnt immediately.

Regarding the second experiment, the educational resource with no creativity is not an easy task, even for students in their second year of computer studies. This could have distracted us from our main goal: to assess whether DesignScrum helps learn all the key agile and creative concepts. Nevertheless, we must admit that DesignScrum validity could be expanded in future versions with a greater number of experiments. For example, students from other Professional Training Degrees and other centers could be included, thus mitigating some of the threats mentioned above.

Last of all, the experiments were kept under control to minimise confusion: all subjects were in the same room while playing the game and they all used the same materials. The fact that the author of this paper was a teacher of these students in the 2021/2022 academic year meant that there was less risk of demotivation, which could have occurred given the small number of participants in this game. All students in this course participated in one of the two experiments.

Conclusion validity is linked to obtaining a specific result from the data treatment we have applied. We are quite convinced that the statistical analysis carried out in this study is correct. In fact, it was considerably broadened in the second version of this paper. These modifications make us even more certain that the analysis is totally impartial. Moreover, the surveys used for both experiments were a useful way to measure all the key indicators.

The results of these surveys, together with expert observation during the experiments, really showed that the concepts had been well understood. Therefore, we can conclude that a lack of understanding was not a threat to the validity of these experiments. Nevertheless, to increase transparency and reproducibility, all data contained in the answers provided by subjects is available online, which enables any interested reader to replicate the analysis. On the other hand, we recognise that it would have been interesting to compare these data with the results of other studies and that it was unfeasible due to the unavailability of certain data from these studies.

Finally, **external validity** refers to how generally the results could be applied to other settings. Unfortunately, as we have already stated, the size and nature of both groups of participants make it impossible to claim that our results could be applied to other contexts. In particular, computer science professionals probably have greater knowledge about agility and creativity that our participants. This means we can neither conclude that the use of DesignScrum improves the learning experience for any kind of student, nor assert that its use would always provide better learning results. In fact, with regard to the scope of these experiments, this proposal could only be applied to academic contexts within the field of computer science. Therefore, we cannot obtain conclusions regarding industrial practices without conducting further experiments in different versions. However, we believe that the proposal can be used in a computer work context because it integrates the theoretical-practical teaching method that is used for the training of this type of professionals at different educational levels and that allows good academic results.

6 | CONCLUSIONS

In this paper, we have presented an educational resource called DesignScrum, which supports the process of teaching agility and creativity in the context of software development by playing a serious game that includes the different elements of Scrum and Design Thinking.

DesignScrum also provides participants with agile and creative techniques which can be used to assess how quickly, easily and accurately task solving can be processed by the human mind.[76]

We have run an experiment with 12 students who were asked to freely build a LEGO structure following a series of steps based on agile and creativity-fostering techniques. This experiment enabled us to prove that participants learn all the key agile and creativity-fostering concepts in a similar amount of time to other well-known teaching resources in this field of knowledge. In general terms, participants also learn these concepts with a high level of motivation towards the learning process. However, the results of this experiment also allowed us to identify that there is room for improvement in some aspects of the proposal, mainly linked to the effects of mental fatigue and participants' different skills when building LEGO structures.

We also run a second experiment in which 12 students from the same class repeated the process, excluding the creativity-fostering steps. This experiment proved that DesignScrum teaches agility in the same way when introducing creativity, without hindering the learning process. We could also include a series of improvements in this experiment, mainly related to the time available to play the game and to participant homogeneity.

We believe that the experiments conducted serve to illustrate and support our proposal, as they demonstrate an improvement in the state of the art, proving that it is possible (to some extent) to teach a wide spectrum of agile and creativity-fostering concepts in an integrated and gamified manner. Nonetheless, conducting more experiments would help to extend the scope of this proposal and challenge some of the threats explained in this paper.

We are already planning to design these experiments so that they can be used in remote teaching environments to adapt to the changes in work that COVID-19 has brought about. To this end, the existing proposals will be adapted to an online format and a series of higher-education centers have been contacted to replicate the experiments with an improved version of DesignScrum.

AUTHOR CONTRIBUTIONS

Carlos Villarrubia: Conceptualization, methodology, software, validation, investigation, resources, visualization, writing – original draft, writing – review & editing. Juan Manuel Vara: Conceptualization, methodology, software, validation, investigation, visualization, writing – original draft, writing – review & editing, funding acquisition. David Granada: Conceptualization, methodology, software, validation, investigation, visualization, writing – original draft, writing – review & editing, funding acquisition. Cristian Gómez-Macías: Methodology, software, validation, formal analysis, investigation, data curation, writing - original draft. Francisco Javier Pérez-Blanco: Methodology, software, validation, formal analysis, investigation, data curation, writing - original draft.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in DeSignScrum–An agility educational resource strengthened w at http://dx.doi.org/10.17632/dztyr22chx.1.

ORCID


Juan Manuel Vara https://orcid.org/0000-0002-8637-6580

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