
ESPE

UNIVERSIDAD DE LAS FUERZAS ARMADAS

INNOVACIÓN PARA LA EXCELENCIA

# Análisis y aplicación de la metodología “Design Thinking” en el desarrollo de plataformas virtuales con elementos gamificados para educación básica en la Unidad Educativa González Suárez

Zurita Gaibor, Diana Kassandra

Departamento de Ciencias de la Computación

Carrera de Ingeniería en Software

Artículo académico, previo a la obtención del título de Ingeniera en Software

Ing. Escobar Sánchez, Milton Eduardo

09 de agosto del 2022

# COPYLEAKS

## application of design thinking in the development of virtual platf…

Scanned on: 3:57 August 4, 2022 UTC

| 0.0% | 0 | 7097 |
|---|---|---|
| Overall Similarity Score | Results Found | Total Words in Text |

| | |
|---|---|
| Identical Words | 0 |
| Words with Minor Changes | 0 |
| Paraphrased Words | 0 |
| Omitted Words | 1523 |

Escobar S.

1710557545

MILTON EDUARDO ESCOBAR SÁNCHEZ

**DEPARTAMENTO DE CIENCIAS DE LA COMPUTACIÓN**

**CARRERA DE INGENIERÍA EN SOFTWARE**

**Certificación**

Certifico que el artículo académico: "**ANÁLISIS Y APLICACIÓN DE LA METODOLOGÍA "DESIGN THINKING" EN EL DESARROLLO DE PLATAFORMAS VIRTUALES CON ELEMENTOS GAMIFICADOS PARA EDUCACIÓN BÁSICA EN LA UNIDAD EDUCATIVA GONZÁLEZ SUÁREZ**" con título de publicación **"APPLICATION OF "DESIGN THINKING" IN THE DEVELOPMENT OF VIRTUAL PLATFORMS WITH GAMIFIED ELEMENTS"** fue realizado por la señorita **ZURITA GAIBOR, DIANA KASSANDRA,** el mismo que cumple con los requisitos legales, teóricos, científicos, técnicos y metodológicos establecidos por la Universidad de las Fuerzas Armadas ESPE, además fue revisado y analizado en su totalidad por la herramienta de prevención y/o verificación de similitud de contenidos; razón por la cual me permito acreditar y autorizar para que se lo sustente públicamente.

**Latacunga, 10 de agosto del 2022**

Firma:

.....

**Ing. Escobar Sánchez, Milton Eduardo**

C.C. 1710557545

**DEPARTAMENTO DE CIENCIAS DE LA COMPUTACIÓN**

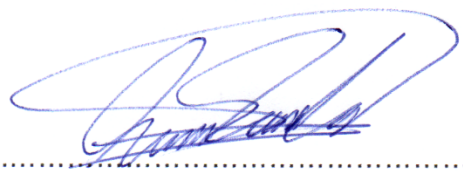
**CARRERA DE INGENIERÍA EN SOFTWARE**

**Responsabilidad de Autoría**

Yo, **ZURITA GAIBOR, DIANA KASSANDRA**, con cédula de ciudadanía n° **1805076153**, declaro que el contenido, ideas y criterios del artículo académico: **ANÁLISIS Y APLICACIÓN DE LA METODOLOGÍA "DESIGN THINKING" EN EL DESARROLLO DE PLATAFORMAS VIRTUALES CON ELEMENTOS GAMIFICADOS PARA EDUCACIÓN BÁSICA EN LA UNIDAD EDUCATIVA GONZÁLEZ SUÁREZ** con título de publicación **"APPLICATION OF "DESIGN THINKING" IN THE DEVELOPMENT OF VIRTUAL PLATFORMS WITH GAMIFIED ELEMENTS"** es de mi autoría y responsabilidad, cumpliendo con los requisitos legales, teóricos, científicos, técnicos, y metodológicos establecidos por la Universidad de las Fuerzas Armadas ESPE, respetando los derechos intelectuales de terceros y referenciando las citas bibliográficas.

**Latacunga, 10 de agosto del 2022**

Firma



.....

**Zurita Gaibor, Diana Kassandra**

C.C.:1805076153

**DEPARTAMENTO DE CIENCIAS DE LA COMPUTACIÓN**

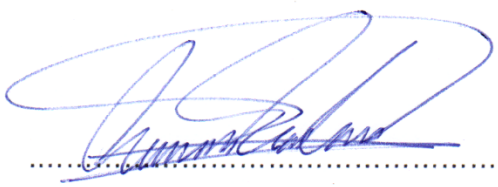
**CARRERA DE INGENIERÍA EN SOFTWARE**

**Autorización de Publicación**

Yo: **ZURITA GAIBOR, DIANA KASSANDRA** con cédula de ciudadanía n° **1805076153**, autor del artículo académico: **ANÁLISIS Y APLICACIÓN DE LA METODOLOGÍA "DESIGN THINKING" EN EL DESARROLLO DE PLATAFORMAS VIRTUALES CON ELEMENTOS GAMIFICADOS PARA EDUCACIÓN BÁSICA EN LA UNIDAD EDUCATIVA GONZÁLEZ SUÁREZ** con título de publicación **"APPLICATION OF "DESIGN THINKING" IN THE DEVELOPMENT OF VIRTUAL PLATFORMS WITH GAMIFIED ELEMENTS"** autorizo a la Universidad de las Fuerzas Armadas ESPE publicar en el Repositorio Institucional: el registro bibliográfico, el resumen y la dirección web indexada en la revista.

**Latacunga, 10 de agosto del 2022**

Firma



**Zurita Gaibor, Diana Kassandra**

C.C.:1805076153

**DEPARTAMENTO DE CIENCIAS DE LA COMPUTACIÓN**

**CARRERA DE INGENIERÍA EN SOFTWARE**

**Carta de Compromiso**

Yo, **ESCOBAR SÁNCHEZ, MILTON EDUARDO**, con cédula de ciudadanía N° **1710557545** en mi calidad de Director del artículo académico: **ANÁLISIS Y APLICACIÓN DE LA METODOLOGÍA "DESIGN THINKING" EN EL DESARROLLO DE PLATAFORMAS VIRTUALES CON ELEMENTOS GAMIFICADOS PARA EDUCACIÓN BÁSICA EN LA UNIDAD EDUCATIVA GONZÁLEZ SUÁREZ** con título de publicación **"APPLICATION OF "DESIGN THINKING" IN THE DEVELOPMENT OF VIRTUAL PLATFORMS WITH GAMIFIED ELEMENTS"**, del autor: **ZURITA GAIBOR, DIANA KASSANDRA**, me comprometo a entregar a la Dirección de Carrera, la dirección web indexada en la revista del artículo en mención, una vez que el mismo sea publicado, con la finalidad de que finalmente sea incluido dentro de los metadatos del Repositorio Institucional.

Firma:

.....

**Ing. Escobar Sánchez, Milton Eduardo**

C.C. 1710557545

ESCUELA POLITÉCNICA NACIONAL

FACULTAD DE INGENIERÍA DE SISTEMAS

ICI2ST SOFTWARE TECHNOLOGIES & INFORMATION SYSTEMS 2022

The Third International Conference on Information Systems and Software Technologies (ICI2ST 2022)

**ACCEPTANCE LETTER:**

Dear Author: **DIANA KASSANDRA ZURITA GAIBOR**

This letter is to certify that the Scientific Paper entitled:

***Application of "Design Thinking" in the development of Virtual platforms with gamified elements***

Paper ID: ICI2ST 2022 - **11**

Has been accepted by the **Scientific Committee** for publication and presentation at the Third International Conference on Information Systems and Software Technologies (**ICI2ST 2022**). The event will be held on virtual mode from November 8-10, 2022 (https://ici2st.epn.edu.ec/index.php/en/).

Quito, August 5th, 2022

Sincerely,

GABRIELA LORENA SUNTAXI ONA

Digitally signed by GABRIELA LORENA SUNTAXI ONA
DN: CN=GABRIELA LORENA SUNTAXI ONA, SERIALNUMBER =1001212204Z, OU=ENTIDAD DE CERTIFICACION DE INFORMACION, O=SECURITY DATA S.A. 2, C=EC
Reason: I am the author of this document
Location:
Date: 2022.08.05 16:36:50-05'00'
Foxit PDF Reader Version: 12.0.0

Gabriela Suntaxi PhD.
**Chair of the Organizing Committee ICI2ST 2022**
gabriela.suntaxi@epn.edu.ec

# Application of "Design Thinking" in the development of Virtual platforms with gamified elements

Diana Zurita-Gaibor
*Software Engineering*
*Armed Forces University ESPE*
Latacunga, Ecuador
dkzurita@espe.edu.ec

Milton Escobar-Sánchez
*Software Engineering*
*Armed Forces University ESPE*
Latacunga, Ecuador
meesacobar1@espe.edu.ec

Ximena López-Chico
*Software Engineering*
*Armed Forces University ESPE*
Latacunga, Ecuador
xrlopez@espe.edu.ec

***Abstract*— This article presents the development of a virtual platform with the Design Thinking methodology and gamified elements, to strengthen the teaching-learning process in the teachers of the González Suárez Educational Unit. This research arises from the need of a virtual platform with gamified elements that are free, easy to use, interactive and motivational. In this study user stories with the agile POV format, test cases to verify the functionality and abuse cases for robustness and to prevent the vulnerability of the virtual platform are used, as well as a b-Learning approach for testing in the classroom. Obtaining in the end as significant results a high and satisfactory assessment of the use of the virtual platform.**

***Keywords*— *Design Thinking, gamification, virtual platform, COVID.***

## I. Introduction

The COVID-19 pandemic forced a profound change in several areas of society, including financial, labor, and especially at the educational level. This has led to the need for the use of educational platforms and tools that support the teaching-learning process and the use of virtuality [1].

Because of this, educational institutions have been forced to use and manage technological resources that help tele-education [2]. This research focuses on the analysis and use of the development methodology "Design Thinking" which facilitates the implementation of gamified elements. This methodology is relevant because it allows greater interaction with the user, and provides better opportunities to obtain adequate feedback. It should be noted that there are proven development methodologies such as Kanban, Xtreme or XP, as well as some experimental methodologies such as the one proposed by Lopez and Montaluisa for software development in the "Software Factory" [3]. However, there is a need to implement new methodologies that change the paradigms and allow users to be much more involved in the virtual educational process [4]. As an alternative solution, it is proposed to analyze the "Design Thinking" methodology, establishing its advantages and disadvantages at the time of its application. It is important to point out that one of the characteristics used are the user stories coming from agile methodologies such as SCRUM, XP, among others [5]. In addition to this, it is important to take into consideration the security of online applications (virtual platform) through the generation of abuse cases [6].

Franziska Dobrigkeit [7] proposes in her research that the Design Thinking (DT) methodology is a key factor if used appropriately within the software creation process. This coincides with what is stated by Hayes Elisabeth [8], who points out that this methodology allows abstracting the physical world to a software architecture. On the other hand, it is necessary and important to emphasize that several studies show that gamification elements produce positive results when properly applied resulting in a more effective teaching-learning process (TLP) [9],[10]. This is beneficial for both students and teachers [11].

Taking this preliminary analysis as a reference, the present research focuses on the analysis and application of the "Design Thinking" methodology within the educational environment of the González Suárez Educational Unit (GSEU) (basic education) and its interaction with gamification elements, all this through the use of a virtual platform. In addition to this, it is important to emphasize the need of using a software functional testing model [12] that allows establishing in a methodical and formal way the improvement of the quality of the final applications, through the use of an adequate testing process [12]. Another relevant aspect to highlight is the need to apply abuse cases to ensure the robustness and prevent the vulnerability of the virtual platform [13] thus improving its security and usability [14].

The article has been organized as follows: Section 2 expands the state of the art on which this research is based; Section 3 presents the analysis and application of the methodology, as well as its interaction with the other elements proposed in the frame of reference; Section 4 determines an evaluation of the results previously obtained; and finally, Section 5 proposes the discussion and conclusion concerning the results obtained.

## II. State of the Art

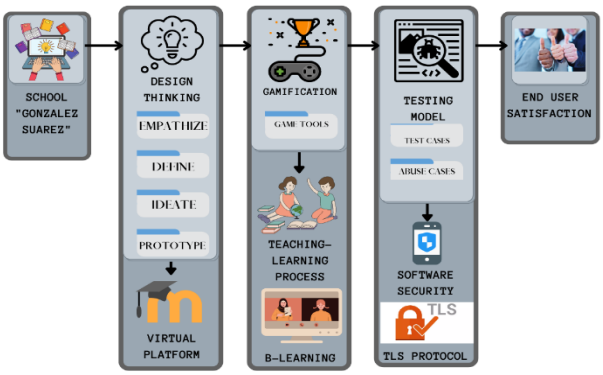



Figure 1. Reference framework for the research.

According to the proposed diagram, the first step for the creation of this virtual platform is its conceptualization and subsequent prototyping following the steps proposed within

the Design Thinking methodology. Kaur [15] defines Design Thinking as a methodology that consists of thinking and empathizing with the user before doing. Initially, it was created with the intention of generating physical products, however, service and complex software systems are the ones that benefit the most from it [16]. DT groups a set of practices with an empathetic, creative and rational approach to satisfy user needs [17]. Through this approach, three essential areas of software are improved: feasibility, desirability and specification [18]. Although there are several strategies and defined steps for Design Thinking, they all follow a similar structure [19], so this research project focuses on the stages that are most commonly used by different development teams, these are:

- Empathize: Understand the user's needs through tools that help to glimpse their environment and needs.
- Define: Establish the user's needs in terms that help to understand it as a problem to be solved.
- Ideate: Propose a solution to the problem.
- Prototype: Make an example of the proposed solution.
- Testing: Obtain feedback and iterate in the process to improve the perception of what the user wants with each iteration.

The next element of the proposed diagram in Fig.1 is the application of gamified elements within the platform. Gamified elements can be used in various contexts, especially in the educational environment. According to Moreira [20], the implementation of these elements greatly reduces school dropout, lack of motivation, and reluctance in the teaching-learning process.

The inclusion of gamified elements within the virtual platform is caused due to the other benefits it offers within the teaching-learning process, some of these benefits are [21]: better retention of information in the long term, greater student participation, greater student proactivity within the educational environment, among other beneficial effects for students and teachers.

There are methodologies for the improvement of TLP, an example of this is the flipped classroom that allows better interaction between teachers and students, but more relevantly guarantees interactivity, development of motivation, and contributes to a transformation of traditional teaching [22]. These same benefits are provided by gamification; however, the latter is much more versatile for working with schoolchildren [23].

Another important element within the analysis of the platform is B-learning (Blended Learning), which is defined according to Maryam Tayebinik as a mix between traditional (face-to-face) education and virtual education [24]. Among some of the benefits of B-learning are: increased student participation, improved student-teacher communication, personalization of education, among others [25].

In addition, it should be noted that an approach to education based on b-learning needs the following elements: 1) instructional design to develop the TLP, 2) the type of content and 3) the objectives to be achieved [26]. In order to establish which of the two most used models for instructional design (ADDIE and SAM) is the best, 5 analysis criteria are determined [27] with their respective results shown in Table 1.

TABLE I. ANALYSIS OF INSTRUCTIONAL MODELS

| **Criteria** | **ADDIE** | **SAM** |
|---|---|---|
| Speed | Slow | Fast |
| Process | Linear Process | Cyclic Approach |
| Defect Detection | Late | Early |
| Collaboration | Little Customer Contact | Customer Feedback |
| Profitability | Not so much (Little) | It is more (Much) |

SAM outperforms ADDIE in all the criteria presented in Table 1, since ADDIE has a slow development speed, has a linear process similar to waterfall, errors can only be detected in late stages, there is very little contact with the customer and it is not very profitable. On the contrary, SAM has a fast development speed, uses a cyclic approach, errors can be detected from the beginning, has customer feedback and is more cost-effective, making it the most appropriate model for the present project.

As shown in Figure 1, after the first 4 steps of Design Thinking (empathize, define, ideate and prototype) and the application of gamified elements, it is necessary to perform usability tests to validate user satisfaction. Among the most common usability tests are [28], [29]: use cases, content validation and user experience tests.

Additionally, abuse case tests will be performed to ensure the security and robustness of the software, these tests are defined by Santana Katherine [30] as "a way or a tool that allows getting into the mind of the aggressor agent", through these tests it is possible to analyze and reinforce possible vulnerabilities that exist within the code and lead to cyber-attacks.

Based on this background, this article proposes the application of different methodological and gamification elements with the objective of carrying out an analysis to evaluate their advantages and disadvantages in an educational environment.

## III. ANALYSIS AND APPLICATION OF THE METHODOLOGY

The present research is descriptive, correlational and experimental [31]. Descriptive because it allows us to analyze and identify the current state of the use of gamification in the teaching-learning process (TLP). Correlational because having more than one research variable demonstrates the association between them. And Experimental since there is manipulation of variables by the researcher. All this will contribute to the improvement of the teaching-learning process, through the development of virtual platforms with gamified elements for basic education of the GSEU developed with the Design Thinking methodology.

This project requires the use of gamified elements (games - ludic interest) which should consider a structure that has the following six components [32]: 1) theme, 2) objective, 3) role, 4) rules, 5) rewards and 6) evaluation. It should be noted that these components are the fundamental basis for the use of gamified elements, which are inserted in the virtual

platform of the GSEU and supported by the Design Thinking methodology.

Taking this preliminary analysis as a reference, this research focuses on GSEU teachers, since they are direct users of this study. They themselves identify the needs and requirements necessary for the development of the virtual platform with gamified elements since they are closely linked to the teaching-learning process. On the other hand, the authorities and students of basic education of the GSEU are taken into consideration as indirect users.

Design Thinking methodology, used in this research project consists of the following phases [33]: Empathize, Define, Ideate, Prototype and Test. Their respective application within the present research project is described below:

### *A. Empathize*

A first approach is carried out to identify the users, their preferences and needs in order to understand their environment. It should be noted that this phase meets the proposed objectives of the "people development" and "learner analysis" phases of the SAM model [34]. For which the following instruments are used: 1) Interviews, 2) Surveys that allow to know the environment in which the user interacts with other users (technical and social). 3) Cognitive immersion in order to place the development team of the virtual platform for the GSEU in the user's place, placing them within their work environment.

### *B. Define*

The information gathered in phase A (empathize) is filtered and the most relevant for the project is selected. For which a discussion is carried out where the facts that cause the problem to be solved are expressed, using the Ishikawa Diagram, in order to correctly determine the problem.

In conjunction with this, user stories are created using the Agile PoV format [35], in order to define the system requirements.

### *C. Ideate*

This phase focuses on the creativity of the development team, proposing various solutions to solve the problem. For this purpose, a brainstorming and a subsequent selection process are used, considering technical (hardware - software), educational (curriculum), gamification (games) and teacher's needs (technological support) criteria.

### *D. Prototype*

Phase that allows to establish a preview of the solution of a problem, through the creation of a prototype, which is closely linked to the progress of the team. It should be noted that this serves the same purpose as the "rapid prototyping" phase of the SAM model [34]. In its first versions it is characterized by being rough and basic in order to gather user's feedback [35]. Prototyping is closely linked to the generation and application of tests. Requiring continuous revisions to polish the final product.

Using the Moodle platform as a base, through the generation of a template model based on the criteria (technical, educational, gamification, and teacher's needs) previously established in phase C (Ideate), a minimum viable product (MVP) that allows solving the problem presented is generated.

### *E. Test*

The last phase of the methodology proposed in this research, it fulfills the same objective of the "testing" process of the SAM model [34]. In this stage the achievements obtained through the iterative review of the MVP by the direct users (GSEU teachers) are evidenced. The users validate the usefulness of the gamified elements, which are implemented within the virtual platform. Based on the following evaluation criteria: usability, level of acceptance and applicability to the teaching-learning process. Additionally, test and abuse cases were carried out to check the robustness and avoid the vulnerability of the virtual platform in order to optimize its security and usability.

## IV. EVALUATION OF RESULTS

In this section the results obtained in each of the phases of the methodology applied in this research, called "Design Thinking", are detailed. The tests are carried out iteratively with the participation of the user (teacher) and experts in the area of systems, pedagogy and education, evidencing their satisfaction at the moment of using the virtual platform. Obtaining valuable information that is stored in the files of the GSEU vice-rectorate, which will be used in future improvements to the developed architecture. Increasing the possibility of improving the efficiency and quality of subsequent versions of the virtual platform with gamified elements for basic education at GSEU. A detailed description of these results is presented below:

### *A. Result of the Empathize phase*

In this phase, research instruments such as interviews and surveys are applied to direct users (teachers) and indirect users (authorities and students), additionally a cognitive immersion is performed by the developer of this research work, with the objective of obtaining a global understanding of the direct user's environment. The results obtained from the application of these instruments are detailed below.

*1) Interview:* Teachers expressed the problems they faced during the COVID-19 pandemic, mentioning that they were forced to understand the use and application of technological tools and instruments for the so-called "virtual classes", or better known as tele-education, for which they used tools such as Google Meet and Google Classroom, which are free access platforms. In addition, the authorities stated that since they did not have their own technological infrastructure, they adopted these tools and instruments. However, a weak level of knowledge in the use of these tools was highlighted, due to the use of the traditional educational model approach (face-to-face education), resulting in demotivation and low student attention due to the monotony and lack of interactivity of the virtual classes.

*2) Survey:* Students express their dissatisfaction regarding tele-education, stating that their parents preferred to postpone their educational process for at least one year, due to the low academic level and their inability to use virtual platforms.

Consequently, from the results expressed in the interviews and surveys, GSEU decided to take measures to mitigate the problems presented providing training courses. Unfortunately, the expectations and needs of the virtual teaching-learning process were not met due to the lack of familiarity with the

use of technological tools that facilitate the dynamics of the educational system within virtual platforms, as is the case of gamification, so the teachers were forced to follow their academic planning in a physical way causing high levels of stress and anxiety in them.

*3) Cognitive immersion:* The developer conducts an experimental test, with the intervention of teachers and students, selectively identifying the gamified elements that meet the needs of the educational system and that will later be considered for use within the virtual platform.

## *B. Result of the Define phase*

In this phase, an Ishikawa diagram is used, where four causes are determined as shown in figure 2, numbers 1,2,3,4 and four effects as shown in numbers 5,6,7,8. In relation to the study problem previously presented in phase A (Empathize), the following problem is exposed: "Underutilization of educational platforms and gamified technological tools by Basic Education teachers within the GSEU ".

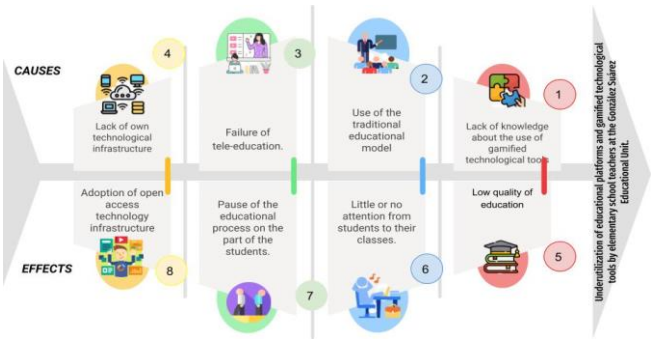



Figure 2. Ishikawa diagram.

Additionally, it is necessary to complement the development of the virtual platform through the generation of user stories, using the Agile PoV (Point of View) method. The most relevant ones are presented below.

*1)* As a [Teacher] ("who"), I would like to [know how to use gamified technological elements] ("what"), to [improve the teaching-learning process] ("why").

*2)* As an [GSEU Authority] ("who"), I would like to [have my own infrastructure] ("what"), to achieve [solving the underutilization of virtual platforms ] ("why").

*3)* As a [Student] ("who"), I would like to [have an interactive and dynamic process] ("what"), to achieve [better learning and higher level of knowledge] ("why").

## *C. Result of the Ideate phase*

During this phase, ten ideas are proposed through Brainstorming, considering criteria from the technical (GSEU infrastructure), educational (pedagogical needs), gamification (game tools) point of view and the needs of teachers. These were filtered through voting and prioritization of needs by the development team together with the direct users (teachers), reducing them to five ideas. Subsequently, these ideas, depending on the requirements of the users, the technological architecture, the needs of the teaching-learning process and the considerations regarding the virtual platform (friendly, interdynamic and bidirectional), are summarized in one.

Therefore, the proposed solution to be developed is to adapt the Moodle virtual platform with gamified technological elements that, according to the teacher's criteria, are free, easy to use, interactive and motivational.

## *D. Result of the Prototyping phase*

For the prototype, the Moodle virtual platform is used as a base, since this is a gamified learning platform that has an efficient design, is compatible with mobile devices, has a large number of tools that can be customized and modified according to the user's needs [36].

In order to test the application of the Design Thinking methodology to create virtual platforms, an MVP (minimum viable product) is developed, designing a template with resources previously identified in phase C (Ideate), related to the planning of the subjects of Language and Literature, Mathematics, and Natural Sciences, including links that lead to gamified technological elements (free online games), which are in correspondence with the topics of each subject, as shown in Figure 3.

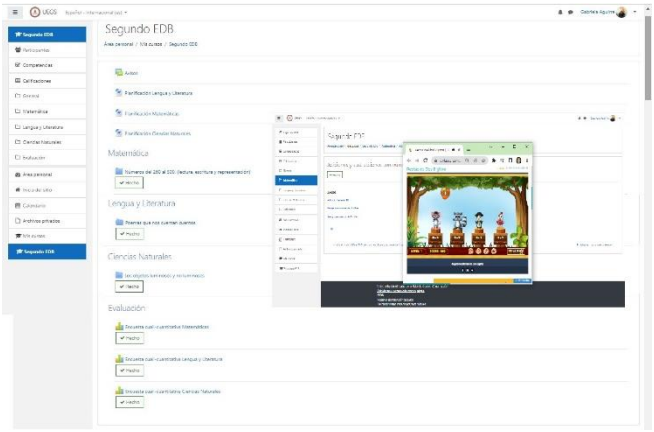



Figure 3. Screenshot of the virtual platform for the second year of basic education.

## *E. Result of the Test phase*

In this phase, the virtual platform is validated by direct users and experts (in the area of systems, pedagogy and education). In addition, it is important to clarify that teachers use the b-learning approach (blended learning) that combines face-to-face learning and online activities, for which they use the resources available on the virtual platform during the face-to-face classes, and then evaluate and collect evidence of the process as shown in Figure 4.

Figure 4. Resources of the virtual platform applied in the classroom of the second year of basic education.

Simultaneously with the testing of direct users and experts. The development team performs functionality tests of the virtual platform, using the functional testing model proposed by Escobar [12], which consists of the following four phases: 1) Specification, 2) Planning, 3) Execution and 4) Evaluation of results (see Figure 5). This model is applied through an iterative evaluation. In addition, it should be noted that the use of abuse cases is added to phase 1 (Specification) in the "Risk Analysis" process. The following is a description of each of these phases:

1) Specification: The functional, access security and service continuity problems of the virtual platform are analyzed using test cases and abuse cases to determine the failures found. If the direct users (teachers) are satisfied, the next phase "Planning" is continued, otherwise the problems are reconsidered.

2) Planning: The time and order in which the corrections of the errors found in the virtual platform are carried out is projected, establishing cycles (in this case 5), likewise the analysis of these errors is carried out according to their functionality, applying test cases and adding abuse cases to model security requirements.

3) Execution: Error corrections are made according to what was projected in phase 2 (Planning). Correlating the versioning of the virtual platform according to the corresponding cycle.

4) Evaluation and results: The number of bugs corrected and the optimization obtained by running the tests is indicated, generating a conclusive report. To verify that the virtual platform meets the criteria indicated by the direct users. The information obtained is also stored in the archives of the GSEU vice-rectorate (historical), in order to use them for continuous improvement.

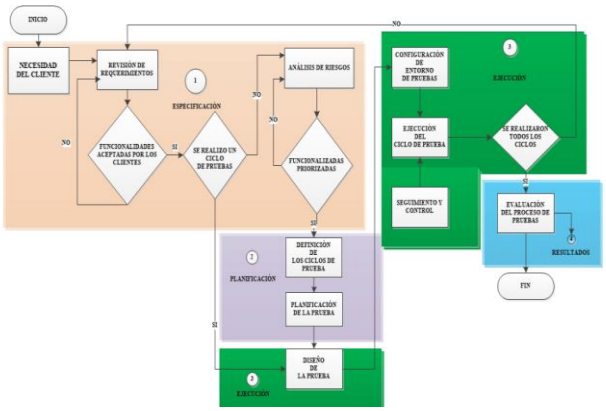



Figure 5. Model proposed by Escobar for Functional Software Testing.

Five usability tests are applied to direct users, and the functionality of the virtual platform is evaluated, recording the incidents presented, which are classified according to their criticality (High, Medium, Low), as shown in Figure 6. Throughout each of the tests performed, it can be seen that the level of incidents is reduced exponentially as they are executed. It can be concluded that several errors associated with the functionality of the virtual platform were eliminated, with the last test achieving a low level of incidents associated with the design of the interface.

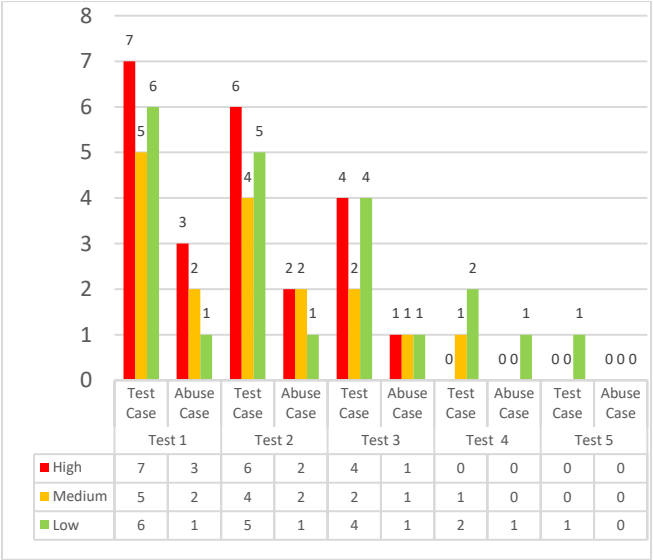



Figure 6. Criticality of the incidents of the virtual platform with gamified elements.

On the other hand, the usability assessment is carried out through a qualitative-quantitative survey, applied iteratively in a study group of 18 teachers from second to seventh year of basic education belonging to the GSEU, for a period of 5 weeks in which user satisfaction is measured in relation to the use of the virtual platform and identification of possible improvements to be implemented. The platform is evaluated through a numerical scale from 1 to 10, obtaining during the 5 usability evaluations an average satisfaction level of 5, 5.8, 6.2, 7.5 and 8.8, respectively. The results obtained in the last evaluation are shown in Table 2.

TABLE II. EVALUATION TABLE OF THE QUALITATIVE-QUANTITATIVE USER SURVEY

| **Evaluation Criteria** | **Rating** | | | |
|---|---|---|---|---|
| | ***Adequate*** | ***Not Adequate*** | ***Requires Changes*** | ***Score*** |
| ***Questions associated to the virtual platform*** | | | | |
| Motivates learning | 16 | 0 | 2 | 8 |
| Facilitates the retention of information and reinforce content. | 15 | 0 | 3 | 8 |
| Facilitates self-learning and individualizes learning | 15 | 0 | 3 | 8 |
| Offers a better presentation of the contents | 15 | 0 | 3 | 8 |
| The knowledge presented is novel | 16 | 0 | 2 | 9 |
| Templates have implemented new and innovative activities | 16 | 0 | 2 | 9 |
| ***Questions associated to the implementation of Gamified elements*** | | | | |
| The gamified elements are in line with the development and structuring of the contents of the course. | 16 | 0 | 2 | 9 |
| The gamified elements clarify the contents of the subject for a better understanding. | 16 | 0 | 2 | 10 |
| Gamified elements link the new information or problem with the previously acquired knowledge. | 15 | 0 | 3 | 10 |
| Gamified elements use familiar ideas and information to understand something new | 16 | 0 | 2 | 9 |

| | | | | |
|---|---|---|---|---|
| Average | 15,6 | 0 | 2,4 | 8,8 |
| Percentage (%) | 86,67 | 0 | 13,33 | 88 |

As shown in Table 2, 86.67% of teachers consider that the virtual platform with gamified elements is adequate, while 13.33% say that it requires changes. A rating of 88% out of 100% was obtained.

The expert validation was carried out using the same criteria applied in the user survey, taking into consideration the level of knowledge and expertise in the area of systems, pedagogy and education in a group of 18 individuals. An average score of 8.6 was obtained, as shown in Table 3.

TABLE III. EVALUATION TABLE OF THE QUALI-QUANTITATIVE SURVEY TO EXPERTS

| **Evaluation Criteria** | **Rating** | | | |
|---|---|---|---|---|
| | ***Adequate*** | ***Not Adequate*** | ***Requires changes*** | ***Score*** |
| ***Questions associated to the virtual platform*** | | | | |
| Motivates learning | 15 | 0 | 3 | 8 |
| Facilitates the retention of information and reinforce content. | 16 | 0 | 2 | 8 |
| Facilitates self-learning and individualizes learning | 17 | 0 | 1 | 8 |
| Offers a better presentation of the contents | 17 | 0 | 1 | 8 |
| The knowledge presented is novel | 16 | 0 | 2 | 9 |
| Templates have implemented new and innovative activities | 16 | 0 | 2 | 9 |
| ***Questions associated to the implementation of Gamified elements*** | | | | |
| The gamified elements are in line with the development and structuring of the contents of the course. | 16 | 0 | 2 | 9 |
| The gamified elements clarify the contents of the subject for a better understanding. | 16 | 0 | 2 | 9 |
| Gamified elements link new information or problems with the previously acquired knowledge. | 16 | 0 | 2 | 9 |
| Gamified elements use familiar ideas and information to understand something new | 15 | 0 | 3 | 9 |
| Average | 16 | 0 | 2 | 8,6 |
| Percentage (%) | 88,89 | 0 | 11,11 | 86 |

As shown in Table 3, 88.89% of experts consider that the virtual platform with gamified elements is adequate, while 11.11% indicate that it requires changes. A rating of 86% out of 100% is obtained.

As shown in Figure 6, after the application of abuse cases during the 5 tests, obtaining 3 high incidents, 2 medium and 1 low, respectively. Two problems related to the security of the virtual platform were concluded, and their solutions were detailed:

*1) Theft of users and passwords:* To solve this problem, the following options provided by Moodle are configured*:*

*a) Protection for usernames:* Setting this option allows the following message to be presented when the teacher resets their password and enters their username or email: "*If you have supplied a correct username or email, an email should have been sent to you*". This prevents an attacker from using the interface to determine which usernames and e-mails are in use on valid accounts [33].

*b) Password policies:* After having reviewed the configuration, it was verified that it is enabled by default, which is available as of version 2.0. Forcing the user to establish a stronger password with a minimum length of 8 characters that includes: uppercase letters, lowercase letters, numbers and non-alphanumeric characters [37]. Additionally, passwords are stored with MD5 encryption (128-bit cryptographic reduction algorithm), and since it is a HASH algorithm, it can't be reversed [37].

*2) Denial of service of the platform:* To find alternatives to mitigate this problem, Moodle is uploaded to the hosting "Byethost" using a free trial, and a DDoS attack (Denial of Service Attack) is performed, using the tool "LOIC" to send a large number of UDP, TCP and HTTPS requests, testing the hosting where the virtual platform is hosted to see to what extent it can withstand this type of attacks. After verifying that this hosting is not capable of withstanding this type of attacks, an investigation is carried out to find a hosting that provides protection against DDoS attacks. The result was "Vis hosting", a paid hosting that provides DDoS protection within its contract; another alternative is to divert the traffic of the virtual platform using a paid external filtering service such as "CloudFlare" and activate the TLS 1.3 (Transport Layer Security) certificate since it is robust and allows the mitigation of vulnerabilities as mentioned by Escobar in his prototype of TLS Certificate Implementation [38]. On the other hand, Moodle recommends placing the "moodledata" folder (location of the installation data) in a different folder from where the public data is located [38].

## V. DISCUSSION AND CONCLUSION

COVID-19 forced the reformulation of the teaching-learning process, causing the change from the traditional pedagogical model to tele-education, prompting teachers to adapt to the new educational system where they are forced to use and apply technological tools. However, the abrupt change caused a substantial decrease in the quality of the teaching-learning process (TLP), evidencing the weak level of knowledge on the part of teachers about the use and management of virtual platforms and their resources. Within this framework, gamification emerges as an alternative to the traditional educational model, facilitating the dynamics of the educational system within virtual platforms.

In this research, the Moodle platform is adapted with gamified technological elements, based on the criteria (technical, educational and gamification) and the needs of 18 teachers (from second to seventh year of basic education) under the methodological framework Design Thinking, solving the underutilization of educational platforms by them. For this purpose, a virtual platform is developed using Moodle, where a template is generated in which the information corresponding to each grade, subject, and their respective resources with gamified technological elements (free online games) is included, as well as a survey for their

evaluation. For the evaluation of the virtual platform, test and abuse cases are used, simultaneously a b-learning approach is used for the classroom tests, with this, evidences and feedback are collected from teachers, thus obtaining the assessments of direct users (teachers) and experts, through a qualitative-quantitative satisfaction survey, 86.67% of teachers and 88.89% of experts consider that the virtual platform with gamified elements is adequate and supports the teaching-learning process, while 13.33% of teachers and 11.11% of experts refer that it requires changes in relation to information security. For which, the solution was the configuration of protection for user names and password policies together with the selection of the hosting service "Vis hosting", the filtering service "CloudFlare", the activation of the TLS certificate and the file protection of the server hosted in "Vis Hosting" [38]. These measures reinforce the security of the virtual platform, however, they can present flaws and be breached, as mentioned by Sanchez and Parra [39].

In relation to the present work, there are investigative references such as the one conducted by Arias, Jadán and Gómez (2019) [40], who use Design Thinking and Game Thinking, and introduce the use of disruptive technologies (technologies to replace a process) in the classroom through playful strategies and the philosophy of design thinking for its didactic application, obtaining innovative results. The aforementioned author uses the b-learning technique through a Moodle platform, in correspondence with the planning of their respective activities. The present research shares some points in common such as: the use of the virtual platform (Moodle), the educational level with which it works (basic education) and the use of the Design Thinking methodology, having as coinciding results innovation, interactivity and therefore an improvement in the TLP.

Although the results were mostly positive it is necessary to mention some limitations that were presented in the present research work, one of them is that the Design Thinking methodology tends to simplify the problems a lot, opting for creative solutions often idealizes a fast and fluid process, which is unrealistic, consequently, problems often occur during the workflow. A feasible solution is to take the best-case scenario as a baseline and then progressively continue with a less ideal scenario [41]. On the other hand, teachers felt insecure about using an unfamiliar virtual platform after their previous experience with other platforms during confinement, but upon understanding that it is an interactive and easy-to-use platform, they agreed that it was not as difficult as they had imagined. Another limitation was that when using external resources (free online games), their availability is variable.

The last limitation to highlight is the long duration of the sustainability of the project, since, being user-centered, it is necessary to dedicate considerable time to the research process, schematization, evaluation and testing with real users, actions that must be repeated in order to reevaluate the alternatives and start the process again. This implies the use of a certain amount of time and resources to obtain a satisfactory product; however, although the development team is capable of giving its time, not all users have the same possibilities.

Based on the results obtained and in correspondence with the research objectives, it is concluded that gamification and the Design Thinking methodology contribute significantly to the development of the TLP within a virtual educational system; It was visualized that GSEU teachers had weaknesses in the use and management of platforms and the use of gamified elements for which the need to insert the "game" as a didactic and innovative strategy within this process with the creation of an MVP was identified; yielding as important results a high level of satisfaction of both users and experts with the implementation of the Design Thinking methodology in the development of virtual platforms supported with gamified elements.

Based on the above, we plan to improve the internal architecture of the project to turn it into a "scalable architecture" and replicate it in other educational units with similar characteristics, as well as its implementation in the General Unified High School.

## REFERENCES


[1] F. Bravo and T. Quezada, “Virtual education at the university in times of Covid-19 - Educación virtual en la universidad en tiempos de Covid-19”, *Espíritu Emprendedor TES*, vol. 5, n.º 1, pp. 154–166, 2021. [Online]. Available: https://doi.org/10.33970/eetes.v5.n1.2021.238

[2] I. Valero, “Tele-education and quality control in universities: Work organization trends in times of Covid-19”, *Revista Visión Gerencial*, vol. 20, n.º 2, pp. 346–360, 2021.

[3] X. Lopez and E. Montaluisa “Organizational structure and methodology for software development in the "Software Factory" of the ESPE Extension Latacunga - Estructura organizativa y metodología para el desarrollo de software en la “Fábrica de Software” de la ESPE Extensión Latacunga”, M.S. Thesis, Universidad de las Fuerzas Armadas ESPE. Latacunga, Ecuador, 2015.

[4] S. Butt, S. Misra, M. Anjum and S. Hassan, “Agile Project Development Issues During COVID-19”, *Lecture Notes in Business Information Processing*. Cham: Springer International Publishing, 2021, pp. 59–70. [Online]. Available: https://doi.org/10.1007/978-3-030-67084-9_4.

[5] M. Izaurralde, “Characterization of Requirements Specification in Agile environments: User Stories - Caracterización de Especificación de Requerimientos en entornos Ágiles: Historias de Usuario”, M.S. Thesis, Universidad Tecnológica Nacional, Córdoba, 2013. [Online]. Available: https://www.institucional.frc.utn.edu.ar/sistemas/lidicalso/pub/file/Tesis/Anteproyecto_Requerimientos_en_Metodologías_Agiles.pdf

[6] K. Rindell, J. Ruohonen, J. Holvitie, S. Hyrynsalmi and V. Leppänen, “Security in agile software development: A practitioner survey”, *Information and Software Technology*, vol. 131, p. 106488, 2021. [Online]. Available: https://doi.org/10.1016/j.infsof.2020.106488

[7] F. Dobrigkeit and D. de Paula, “Design thinking in practice: understanding manifestations of design thinking in software engineering”, in *ESEC/FSE '19: 27th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering*, Tallinn Estonia. New York, NY, USA: ACM, 2019. [Online]. Available: https://doi.org/10.1145/3338906.3340451

[8] E. Hayes and I. Games, “Making Computer Games and Design Thinking”, *Games and Culture*, vol. 3, n.º 3-4, pp. 309–332, july 2008. [Online]. Available: https://doi.org/10.1177/1555412008317312

[9] D. Dicheva “Gamification in Education: A Systematic Mapping Study”, in *Journal of Educational Technology & Society*, vol. 18, n.º 3, pp. 75–88, 2015. [Online]. Available: http://www.jstor.org/stable/jeductechsoci.18.3.75.

[10] J. Swacha, “State of Research on Gamification in Education: A Bibliometric Survey”, *Education Sciences*, vol. 11, n.º 2, p. 69, 2021. [Online]. Available: https://doi.org/10.3390/educsci11020069

[11] S. Pathak, S. Aggarwal and M. Yashika, "A study on Systematic review of Gamification in Education Sector", in *Journal of Contemporary Issues in Business and Government*, vol. 27, n.º 1, pp. 2154–2166, 2021.

[12] M. Escobar and W. Fuertes, “Formal software functional testing model to reach Integrated Maturity Level 2 - Modelo formal de pruebas funcionales de software para alcanzar el Nivel de Madurez Integrado

2", *REVISTA FACULTAD DE INGENIERÍA*, vol. 24, n.º 39, p. 31, 2015. [Online]. Available: https://doi.org/10.19053/01211129.3549

[13] J. Merchan, F. Astudillo, L. Tello, F. Sanchez, G. Lopez and D. Quiroz, "Information security management frameworks and strategies in higher education institutions: a systematic review", *Annals of Telecommunications*, 2020. [Online]. Available: https://doi.org/10.1007/s12243-020-00783-2

[14] N. Grigoryeva, I. Melikov, N. Palanchuk, I. Melikov, I. Kokhanovskaya, and E. Aralova, "Opportunities for Organizing Distance Learning Presented by the Moodle Platform: Experience in the Conditions of the COVID-19 Pandemic", *Propósitos y Representaciones*, vol. 9, SPE3, 2021. [Online]. Available: https://doi.org/10.20511/pyr2021.v9nspe3.1259

[15] M. Kaur, "Design thinking: A new way of thinking," in *IAHRW International Journal of Social Sciences Review*, vol. 9, no. 1, pp. 11–13, 2021. [Online]. Available: https://www.proquest.com/openview/7cb6b643d567a17f21a9f3814a117d8f/1?pq-origsite=gscholar&cbl=5347679

[16] M. Broy and W. Brenner, "Epilog: From Requirements Engineering to Design Thinking," in *Design Thinking for Software Engineering*. Cham: Springer International Publishing, 2022, pp. 213–215. [Online]. Available: https://doi.org/10.1007/978-3-030-90594-1_15

[17] L. Pereira, R. Parizi, M. Prestes, S. Marczak, and T. Conte, "Towards an understanding of benefits and challenges in the use of design thinking in requirements engineering," in *SAC 21: The 36th ACM/SIGAPP Symposium on Applied Computing*, Virtual Event Republic of Korea. New York, NY, USA: ACM, 2021. [Online]. Available: https://doi.org/10.1145/3412841.3442008

[18] R. Sharma and J. Nath, "Design-Thinking and User's Requirement Engineering: Human Centred Development," in *International Journal of Mechanical Engineering*, vol. 6, no. 19, pp. 108–114, 2021. [Online]. Available: https://kalaharijournals.com/resources/SP-Vol.6_19.pdf

[19] V. Cahui, D. Quispe, A. Condori, and J. Chapi, "Case Studies of Design Thinking in the Analysis and Design stages of Software Development - Casos de Estudio de Design Thinking en las etapas de Análisis y Diseño del Desarrollo de Software", *Innovación y Software*, vol. 3, no. 1, pp. 17–29, 2022. [Online]. Available: https://revistas.ulasalle.edu.pe/innosoft/article/view/50

[20] M. Area and C. González, "From teaching with textbooks to learning in gamified online spaces - De la enseñanza con libros de texto al aprendizaje en espacios online gamificados", *Educatio Siglo XXI*, vol. 33, no. 3, p. 15, 2015. [Online]. Available: https://doi.org/10.6018/j/240791

[21] S. Brull and S. Finlayson, "Importance of Gamification in Increasing Learning", in *The Journal of Continuing Education in Nursing*, vol. 47, no. 8, pp. 372–375, 2016. [Online]. Available: https://doi.org/10.3928/00220124-20160715-09

[22] K. Zickwolf and S. Kauffeld, "Inverted Classroom", in *Handbuch Innovative Lehre*. Wiesbaden: Springer Fachmedien Wiesbaden, 2019, pp. 45–51. [Online]. Available: https://doi.org/10.1007/978-3-658-22797-5_2

[23] C. Dichev and D. Dicheva, "Gamifying education: what is known, what is believed and what remains uncertain: a critical review", in *International Journal of Educational Technology in Higher Education*, vol. 14, no. 1, 2017. [Online]. Available: https://doi.org/10.1186/s41239-017-0042-5

[24] M. Tayebinik and M. Puteh, "Blended Learning or E-Learning?", *International Magazine on Advances in Computer Science and Telecommunications*, vol. 3, no. 1, pp. 103–110, 2014. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2282881

[25] A. Kumar *et al.*, "Blended Learning Tools and Practices: A Comprehensive Analysis", *IEEE Access*, vol. 9, pp. 85151–85197, 2021. [Online]. Available: https://doi.org/10.1109/access.2021.3085844

[26] H. Castellanos Altamirano and E. Rocha Trejo, "Application of ADDIE in the construction process of a distributed b-learning educational tool - Aplicación de ADDIE en el proceso de construcción de una herramienta educativa distribuida b-learning," *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, no. 26, Oct. 2020, Art. no. e1. [Online]. Available: https://doi.org/10.24215/18509959.26.e1

[27] M. Allen, *Leaving Addie For Sam An Agile Model For Developing The Best Learning Experiences*. ASTD, 2012.

[28] C. Mendoza, "Usability of virtual platforms by teachers of public institutions of secondary education in the municipality of Riohacha-La Guajira - Usabilidad de las plataformas virtuales por los docentes de las instituciones públicas de educación media en el municipio de Riohacha-La Guajira", B.S. Thesis, Universidad Distrital Francisco José de Caldas, Cataluma, 2020.

[29] A. Casanova, "User experience in virtual learning environments - Experiencia de usuario en entornos virtuales de aprendizaje", B.S. Thesis, Pontificia Universidad Católica de Valparaíso, Valparaíso, 2015. [Online]. Available: http://repositorio.ucv.cl/handle/10.4151/92467

[30] S. Santana, "Analysis of abuse cases and implementation of the software specification model for security requirements in a use case - Análisis de casos de abuso e implementación del modelo de especificación de software para requerimientos de seguridad en un caso de uso", B.S. Thesis, Universidad de Guayaquil, Guayaquil, 2019. [Online]. Available: http://repositorio.ug.edu.ec/handle/redug/39902

[31] A. Álvarez, "Classification of investigations - Clasificación de las investigaciones", 2020, Universidad de Lima, Facultad de Ciencias Empresariales y Económicas, Carrera de Negocios Internacionales. [Online]. Available: https://hdl.handle.net/20.500.12724/10818

[32] R. Medina and L. Ramirez, "Gamification in Education: Didactic alternative in the adaptation of Pedagogical Designs for training - Gamificación en Educación: Alternativa didáctica en la adecuación de Diseños Pedagógicos para la formación", *Revista Sennova: Revista del Sistema de Ciencia, Tecnología e Innovación*, vol. 6, 2021. [Online]. Available: https://doi.org/10.23850/23899573.3626

[33] F. Pignani, "The new ISO 56000 and traditional innovation methodologies - La nueva ISO 56000 y las metodologías tradicionales de la innovación", *LOGOS*, vol 3(1): 144-157, 2022. [Online]. Available: http://dspace.ulead.ac.cr/repositorio/handle/123456789/173

[34] C. Ní Shé, O. Farrell, J. Brunton, and E. Costello, "Integrating design thinking into instructional design: The #OpenTeach case study," Australasian Journal of Educational Technology, pp. 33–52, Sep. 2021. [Online]. Available: https://doi.org/10.14742/ajet.6667

[35] M. Yusaliano, A. Syahrina, and T. Kusumasari, "User Interface Design of P2P Lending Mobile Application Using Design Thinking," in *2020 12th International Conference on Information Technology and Electrical Engineering (ICITEE)*, Yogyakarta, Oct. 6–8, 2020. IEEE, 2020. [Online]. Available: https://doi.org/10.1109/icitee49829.2020.9271780

[36] E. Egorov, M. Prokhorova, T. Lebedeva, O. Mineeva y S. Tsvetkova, "Moodle LMS: Positive and Negative Aspects of Using Distance Education in Higher Education Institutions", *Propósitos y Representaciones*, vol. 9, SPE2, 2021. [Online]. Available: https://doi.org/10.20511/pyr2021.v9nspe2.1104

[37] Moodle. "Site security settings – MoodleDocs - Configuraciones de seguridad del sitio – MoodleDocs," 2019, MoodleDocs. [Online]. Available: https://docs.moodle.org/all/es/Configuraciones_de_seguridad_del_sitio#Proteger_nombres_de_usuarios

[38] M. Escobar, "Prototype for the Implementation of free TLS Certificates at the DAME Clinic in the city of Quito - Prototipo de Implementación de Certificados TLS gratuitos en la Clínica DAME de la ciudad de Quito," Unpublished M.S. Thesis, Universidad Internacional de la Rioja, Latacunga, 2022.

[39] J. Sánchez and P. Parra, "Vulnerability Analysis of Weak Credentials or Default Web Applications LMS - Learning Management Tools - Análisis de vulnerabilidades de credenciales débiles o por Defecto de Aplicaciones Web LMS - Herramientas de Gestión de Aprendizaje" Ciencia, diseño, tecnología e innovación con responsabilidad social. Ambato: Editorial Pio XII, 2021. 227-238.

[40] H. Arias, J. Jadán and L. Gómez Luna, "Educational innovation in the classroom through Design Thinking and Game Thinking - Innovación educativa en el aula mediante Design Thinking y Game Thinking," *HAMUT'AY*, vol. 6, n.º 1, p. 82, 2019. [Online]. Available: https://doi.org/10.21503/hamu.v6i1.1576

[41] G. Nedeltcheva and E. Shoikova, "Coupling Design Thinking, User Experience Design and Agile," in *the International Conference*, London, United Kingdom, Dec. 20–22, 2017. New York, New York, USA: ACM Press, 2017. [Online]. Available: https://doi.org/10.1145/3175684.3175711