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Gamification and discovery learning: Motivating and involving students in the learning process ☆

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ABSTRACT

The widespread use of new technologies by students has forced universities to include active methodologies in their pedagogy. This process has accelerated due to the COVID-19 pandemic, introducing innovative changes in pedagogy. This has motivated many lecturers to increase student motivation. The need to keep the students' attention during long and tedious theoretical sessions has motivated this contribution. Furthermore, the need for students to develop their Web search skills and development of individual expertise and participation in a final group process that attempts to transform newly acquired information into a more sophisticated understanding has inspired this contribution. This paper presents the results obtained from the implementation of gamification and Discovery Learning instructional model in the Software Engineering subject of the Computer Science degree in the course 2021/2022. The joint use of gamification and the Discovery Learning instructional model through Webquests has never been studied before. They help students to better acquire the knowledge taught in class. The gap in the combination use of gamification and Discovery Learning instructional model compared to previous studies using one single method show an improvement in academic results, greater motivation on the part of the students, greater creativity and ability to put what they have learned into practice.

1. Introduction

The digitalization of recent years has brought many changes in society, and especially in education. Today's young people are digital natives, and their information consumption has completely changed compared to that of their parents. Young people use all digital media to communicate and inform themselves (they are able to use their smartphones, tablets or computers for hours) and universities have realized this. For this reason, universities are trying to adapt to change by trying to include innovative pedagogical methodologies [24,22].

These new technologies allow for better communication between the lecturer and the student. They also make students feel comfortable with tools they already know. Traditional classes are demotivating for them, and they do not pay attention to what the lecturer says. This is one of the main reasons why lecturers are including new technologies in the room. However, these technological advances need to be evaluated as the experience is often not the same from the point of view of students and lecturers [20].

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The ability of being continuously connected through digital devices rivals the ability to concentrate and learn. For this reason, it is necessary to be very thorough when including active methodologies that include new technologies in the room. Always must be taken in mind that such use must be rational and beneficial to the learning process.

It has been shown that the motivation and involvement of students in the learning process is fundamental from the neurological point of view [21]. Therefore, innovative academic proposals have been accomplished in education in order to look for students interest through active methodologies and models as a structure to enhance motivation and implication [13,3].

Due to the COVID-19 pandemic, many of the classes became online from one day to the next. The discouragement of the students increased in this period due to the lack of interaction with classmates and long theoretical and little practical classes [6]. For this reason, one of the priorities for the next courses was to increase their motivation. One of the main challenges that a lecturer faces when it comes to learning is motivation. Motivation is demonstrated by personal choice to engage in an activity and determines the intensity of effort and persistence in that activity [16]. The following year the hybrid classes returned in which 2 days were online and 3 in person. It has not been until the 2021/2022 academic year when the improvement of motivation has been carried out, including gamification and Discovery Learning to the lecture room.

Gamification is a strategic attempt that can turn learning into an immersive activity. Perrotta et al. [34] point out that learning through enjoyment and fun can be a means of introducing students to a state of *flow*. According to Kapp, gamification is "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" [25]. Introducing gamification in the most theoretical part of the subject, aims to make students more motivated. Another objective is that the students can pay attention to what the lecturer says and that they do not disconnect during this process. Students must be focused. The theoretical aspects of all subjects are monotonous but important for students. Then they need these concepts to carry out the practical part and without these concepts, they are not capable. Games must be adjusted to their needs and students' characteristics [44,26]. This is called adaptive gamification, which "is taking care of the gamification that each particular user needs in a particular moment, tailoring the gamification to the users and contexts" [4].

Secondly, "Discovery Learning is seen as a promising way of learning for several reasons, the main being that the active involvement of the learner with the domain would result in a better structured base of knowledge for the learner as opposed to more traditional ways of learning, where knowledge is said to be merely transferred to the learner" [39]. WebQuests are the main exponent of the Discovery Learning instructional model [19]. WebQuests were created in the decade of the 1990s by two teachers, Bernie Dodge and Tom March. Dodge was the one who initially developed this tool, whose purpose was to develop in students the ability to browse the Internet with a clear objective: to learn to select and retrieve data from multiple sources and develop thinking skills critical [10]. As a consequence, WebQuests are a powerful tool to induce students' critical thinking [7]. Critical thinking is a disciplinary process that proposes to analyze, synthesize and evaluate information, in such a way that knowledge is organized, reaching a correct position on a specific topic, at the same time being objective when analyzing or extracting an idea based on the observation, experience, reflection, reasoning attached to communication [11]. Critical thinking skill is fundamental for every software developers and the goal is their further improvement in the lecture room. Furthermore, despite being computer science students, they have difficulties finding information on the Internet when they want to solve a problem. It is very common to receive email from students with a programming problem whose answer is easily found with a simple search. "WebQuest activity is a helpful form of scaffolding for promoting learners' positive learning experiences regarding organizing information and problem-solving and reasoning skills" [40].

Similar to [29] with Discovery Learning with English in Hong Kong, we tried to find the gap of Discovery Learning in Software Engineering subject. Similarly, it is difficult to find papers applying Discovery Learning in Software Engineering subjects [18,23]. The use of gamification in Software Engineering subjects is much more widespread [32,2]. The joint use of Discovery Learning and Gamification has been studied only for gamified Webquests [35,42,28]. Nonetheless, the use of both separately, in different class activities in the same subject has not been studied, and it is a gap that this contribution tries to solve. In addition, this paper focuses on the subject of Software Engineering and tries to evaluate the use of each discipline separately and if, as a whole, has served to improve the academic results.

In this context, this paper presents the experience of adding gamification and Discovery Learning though WebQuests in a Software Engineering subject in a Computer Science degree. The reception of this experience has been quantitatively and qualitatively measured, answering the following research questions:

- RQ1: How can academic results be better?
- RQ2: Why are the students motivated to play with Wooclap and with gamification?
- RQ3: Why does Wooclap and gamification make students study/learn more?
- RQ4: What is the level of participants' agreement about the steps of WebQuest project in terms of introduction, task, process, resources, evaluation, and conclusion?
- RQ5: What are the perceptions of participants towards working with WebQuest projects in terms of planning skills, problems faced, implementation, real-life experience, popular and unpopular features, suggestions, and integration ideas?

The remainder of this document is structured as follows: Section 2 presents related works on the gamification and Discovery Learning instructional model through WebQuests. Section 3 presents the case study of this work, including the motivation and implementation of the initiative. Section 4 describes the results obtained in the experience answering the research questions. Finally, Section 5 presents the conclusions and future lines of action.

2. Related work

The use of several learning techniques in the same subject is not the most common. Most of the papers present only one. It is much more difficult to find papers that combine gamification and WebQuests. However, we can find in the literature a few works that use gamification and WebQuests. For example, Petroulis et al. [35] use gamified WebQuests. They have planned 8 workshops, in which they have developed a WebQuest for each of them. These WebQuests are gamified with quizzes, and the lecturer evaluates and scores the achievements obtained by each group based on the rubric published for this purpose. Espinosa [42] has implemented a WebQuest in which 4 activities have been included. These activities are 4 different games with which students learn English lexis. Finally, Levitt and Piro [28] in a similar way to the previous works wants to gamify the WebQuest to motivate the students of graduate education courses. These teacher training students must create different WebQuests in which the tasks are gamified activities for their students. In this way, students learn how to create WebQuests and also design gamified activities for their students. It can be observed that all these works include gamification directly in the WebQuests, they do not develop two completely differentiated activities. In our case, the theoretical parts use gamification to further engage students and the WebQuests to develop their skills in groups and strengthen what they have learned through the Discovery Learning instructional model.

All these contributions have used WebQuests that have gamified them. In no case have they used both methods separately and check the benefits they could bring. These papers refer to the motivation and involvement of the students in the WebQuests. However, none of these papers refer to academic results, whether they are better, worse or remain the same.

The use of gamification in the educational environment is widespread. There are hundreds of works that have used gamification to motivate their students and try to improve the knowledge of their subjects. For example, Garcia-Cabot et al. [15] have used gamification with 27 students in the Master degree of Software Engineering for the Web. They compare the results obtained by comparing a control group and a group that has used gamification, obtaining better academic results, the latter. This process was carried out over two weeks with 5 teaching hours each. The students felt that gamification was beneficial to introduce the basic concepts of the subject. The platform used for gamification improved the relationships between students and made learning more participatory and motivating for the students. In the process, each assignment was scored, and a ranking was generated with each student's score. Pedersen et al. [33] introduced gamification in the Advanced Quantum Mechanics course, in which 47 students participated. Similarly to the previous study, two groups were compared, a control group and another group in which the course was gamified. The results obtained show better academic results in the group that used gamification. The process lasted 7 weeks, in which in all sessions, between 10 and 20 minutes were dedicated to gamified activities with the objective of learning the basic concepts of the subject. 49 students participated in Kyewski and Krämer's experiment [27], in which they asked themselves whether it was worthwhile to gamify an online subject. The results compare to a control group and surprisingly the academic results were worse in the group that used gamification. The gamified subject was a psychology seminar, and the process took place throughout the semester. The results show that the budgets have no influence in motivating the students with the subject to obtain better academic results or to obtain better results in the quizzes. Sánchez-Martín and Cañada-Cañada [36] gamified the whole semester of the subject Matter and Energy in Primary Education Degree. 36 students were involved, in which two groups were differentiated, a control group and the other group that used gamification. The students who were more involved in the game clearly obtained better academic results. For each game, students earned a number of points based on their achievements. Stansbury and Earnest [38] evaluated 93 students in college psychology courses. These classes lasted the entire course (1 year) with 3 50-minute sessions per week. The comparison between the gamified and control group shows an improvement in academic results. The results show that the students were more motivated, more involved and participative in the subject, as well as enjoying the classes more. For each game, a series of points were obtained and students could acquire different levels based on the results obtained. Finally, Fernandez-Antolin et al. [12] involved 171 students in the architecture degree. Two groups were compared, a control group and another in which the subject was taught gamified. The results show that the students have assimilated the technical concepts better than the students in the control group. They also show a higher motivation and participation on the part of the students. Thus, the academic results have been superior in the gamified group than in the control group.

With the exception of some of the contributions, the academic results were better in the groups or years in which gamification was used. In addition, in these contributions, it can be highlighted that the motivation of the students for the class activities has been increased. However, aspects such as a better structured base of knowledge are not worked on, nor is the ability of learning to select and retrieve data from multiple sources. Something that has not been worked on through gamification could be worked on through Discovery Learning such as thinking skills, critical analyze, synthesize and evaluate information reaching a correct position on a specific topic, at the same time being objective when analyzing or extracting an idea based on the observation, experience, reflection, reasoning attached to communicate.

Like gamification, WebQuests have been widely used in the academic world. There are a large number of works that have used them and studied their results, highlighting their benefits. Yang [41] divided his mathematics students into two groups, a control group with 25 students and an experimental group with 27 students. These 52 students were studied for the entire course. The WebQuests were developed using the PHP programming language. In order to know the learning level of the students, at the end of the tasks the teachers gave a questionnaire to the students. The academic results show better results in the students who used the WebQuests in the learning process. They also show higher satisfaction with the subject, IT capability, higher collaborative learning, learning reflection, and learning feedback. Chen [7] involved 188 Business Management degree students for 16 weeks with 3 hours per week. Five different WebQuests were conducted, and in this case there is no control group. The results show that the use of WebQuests improves students' knowledge acquisition and develops critical thinking. In addition, students show increased motivation for learning. Zendler and Klein [43] divided 51 students into a control and an experimental group. The 25 students

in the experimental group performed better academically than those in the control group. The students accessed their WebQuests through a QR code and had to answer a multiple-choice test upon completion to find out the knowledge level of each of the groups. Soepriyanto et al. [37] conducted an experiment with 65 second year students of the Education Technology degree. These students were not divided into two groups, one of them being the control group. The WebQuests developed are 7 and are hosted on the Zunal platform.[1] The objective was to work on the basic concepts of the Computer Network subject. In addition, they wanted to develop the ability to compare things, organize data, summarize data, evaluate data, synthesize data, and become a better problem solver. The results show great results from the students having been evaluated and seen the improvement of these skills. Finally, Wang [40] used WebQuests to teach programming in the university. The students were divided into two groups, an experimental group with 50 students and a control group with 59 students. The method was used during the whole semester (18 weeks, 3 hours per week) and 4 WebQuests were developed, one for each topic to be worked on. At the end, a questionnaire was administered to find out whether the students in each group had achieved the minimum programming knowledge required. The results reflect better academic results among the students who used the WebQuests. However, in the minimum knowledge questionnaire, there was no difference between the two groups; both groups acquired the necessary knowledge.

In this case, in these contributions to on Discovery Learning, the study of academic results has not prevailed, and it is difficult to highlight whether this methodology improves them. These contributions have highlighted that students show higher satisfaction with the subject, show higher collaborative learning, learning reflection, and learning feedback. Additionally, they concluded that it improves students' knowledge acquisition and develops critical thinking, develop the ability to compare things, organize data, summarize data, evaluate data, synthesize data, and become a better problem solver. However, they have not studied deeply if it increases the motivation of the students.

All these works, although separately, have all tried to improve the academic results of the students, they have tried to improve their learning and motivation. This work has the same objectives, but instead of using one technique separately, it tries to combine them and use the advantages of each of them. Results will show if the combination of gamification and Discovery Learning enhance academic results, motivation and critical thinking.

3. Case study

This section aims to describe the employed gamification process and the Discovery Learning instructional model in detail, starting from its inception and covering its different phases, as well as the methodology of each one.

The experience has been developed in the Faculty of Engineering in the degree of Computer Science. 41 third-year students of the Software Engineering subject have been enrolled in the experience. This process has only been carried out in one part of the subject, the testing part, both static and dynamic testing. This term is the longest in the Software Engineering subject.

3.1. Inception of the experience

In recent years, universities have been immersed in a profound change due to digitalization. Today's students, all of them digital natives, demand new technologies in the educational world. Students use for hours their computers, tablets or cell phones, while university classes still use traditional methods. These classes are very tedious and boring for students, and it is common for them to stop paying attention.

Due to the COVID-19 pandemic, all of us, students and lecturers were forced to stay at home and adapt to online classes. This circumstance made more visible the need for new technologies in the university educational world. The obligation to adapt all the content to the online mode brought with it a great increase in work and dedication on the part of the teaching staff. On the part of the students, the theoretical classes became much more boring and students paid less attention. It also meant that the exercises presented annually were not understood or could not be performed by the students, as they did not have the knowledge previously taught.

With the return to the classroom the following year in a hybrid manner (2 days of online classes and 3 days of face-to-face classes), the traditional delivery method was still a problem. There was a significant difference in student participation between online and face-to-face classes. The face-to-face classes were more dynamic and participatory than the online classes, although overall, classroom participation was low. Online participation was null.

Taking into account the students' need to use technology in the classroom and the need to increase their motivation, the idea was to gamify the theoretical classes. For this purpose, tools such as Kahoot, Quizzizz or Wooclap were studied. The latter allows through the free version that all students of the subject can participate. It is also integrated with Moodle, which facilitates its integration with all the material of the course, since Moodle is the platform used as a base at the university.

On the other hand, students are required to work in groups during the course and especially when the subject of testing is taught. In these group works, students have problems in understanding certain concepts explained in class. To avoid this problem, gamification has been introduced. In addition, students have difficulties in finding the necessary information on the Web to help them solve the problems that arise during the development of the work. Students tend to write emails (if the work is being done outside the classroom) or to ask the lecturer quickly if they do not find answers in a short time. Once they are introduced to the world of work, students lack this help. WebQuests encourage the search for information on the Web. For this reason, different WebQuests

[1] http://zunal.com.

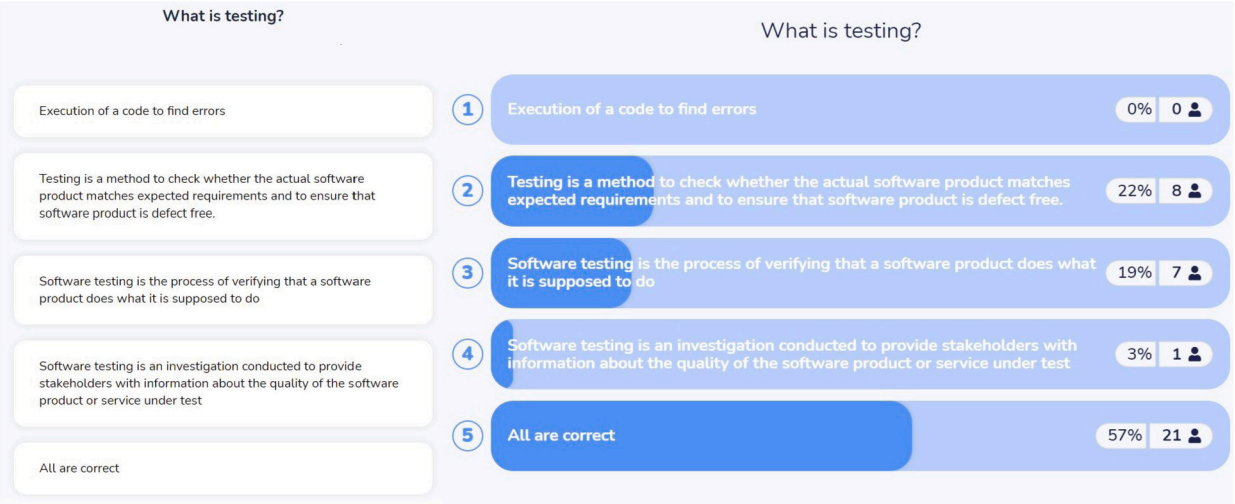

Fig. 1. Wooclap: (left) questions shown to students and (right) answers shown to the lecturer.

have been designed to complete the exercises related to the subject and to help students become more proficient with the search for information.

The WebQuests not only allow to improve the search on the Web. Other main reasons are that "a WebQuest is a scaffolded learning structure that uses links to essential resources on the World Wide Web and an authentic task to motivate students' investigation of a central, open-ended question, development of individual expertise and participation in a final group process that attempts to transform newly acquired information into a more sophisticated understanding. The best WebQuests do this in a way that inspires students to see richer thematic relationships, facilitate a contribution to the real world of learning and reflect on their own metacognitive processes" [10].

3.2. Description of the experience

In this subsection, two totally different processes that have been carried out during this experience will be described. During the theoretical classes, gamification has been included to try to motivate the students. In the same way, with the intention of motivating the students, the practical parts of the subject have been carried out using the Discovery Learning instructional model. Different WebQuests have been developed for this process.

3.2.1. Gamification

Gamification was used in the theoretical sessions of the course. Two parts can be differentiated: the games at the beginning of class to remember the concepts of the previous day and the games during the theoretical session.

At the beginning of the theoretical session, a game was played to reinforce the knowledge taught the previous day. These sessions were less than 10 minutes and were usually multiple-choice questions with 4 possible answers and 1 correct answer. The objective was to test the knowledge of the class before being able to continue with the session. If the question was answered correctly by a large majority of the students, the lecturer did not go into much depth to clarify the concept. However, if the question was answered incorrectly by the majority, the lecturer tried to explain the concept again. The reasons could be an incorrect explanation or that it is a complex concept. Students want to get it right because they get points for each correct answer. At the end of the session they can know their position in the classification with respect to the classmates. They always want to be ahead of their friends. The aim of the game is for the students to learn all the concepts explained in the classroom, as well as to have fun. Wooclap has been used in this part, which is a dynamic tool that allows students to participate in gaming during the class, through real-time interactions that provide us with immediate feedback.

During theory sessions, students tend to stop paying attention. If the lecturer is talking for more than an hour, it makes the classes boring and difficult to follow. Although the lecturer can ask questions to the students to try to attract their attention, it is not possible to get the attention of all students. Therefore, the frequent introduction of questions makes it difficult for the student to disconnect. If they are dynamized using the gamification technique, the students feel more motivated. As at the beginning of the class, correct answers score points. At the end of the class, the one with the most points wins. Fig. 1 shows an example about a question performed in class. On the left, it is shown the screen that the students see with the question and the different options. On the right, the screen that the lecturer sees with the different answers given so far by the students.

3.2.2. Discovery learning

The Discovery Learning instructional model was used for the practical sessions of the course. The WebQuests have allowed us to carry out this instructional model. Among the objectives are to motivate students to face the challenges presented to them through

Table 1
Student results the courses 20/21 and 21/22.

20/21			21/22		
#Students	AVG mark	#Fails	#Students	AVG mark	#Fails
32	5,22	12	41	6,06	9

the WebQuests. Another objective is for students to learn or improve their research skills. Students should be able to search for and find relevant information to help them solve problems that arise. They should not go directly to the teacher when they have problems, they should look for a solution on their own. Students should also gain their own expertise on the topic being worked on, as well as learn to work in groups. For this reason, the work developed through WebQuests is always group work.

Although the process section of the WebQuest identifies the steps to be followed, students must plan and develop their tasks in order to achieve the objective that is set for them. They are always provided with material through videos, blogs, books, etc. This material is not enough, but it is a great help to get them started with the tasks. Students decide how far they want to go, as they are provided with a rubric with which the teacher will evaluate their work. The WebQuest developed for students was about how to learn and use Katalon, a free solution for Web test automation.

4. Results

This section shows the main results obtained from the student results of the courses 20/21 and 21/22 and the surveys conducted to gather the opinion of the students, followed by an analysis of each of the research questions. The questions in Table 2 have been based on [5] work, and questions in Table 3 are based on [14] work. For the questions in Tables 4 and 5, we have taken as a basis the work [17].

4.1. Research method

Settings: The study was conducted in Mondragon University (Arrasate - Mondragon, Spain). All participants used their own laptops during the course, and they had to use a browser and Katalon to complete their tasks.

Procedure: It has been explained in detail in the subsection 3.2. Finally, at the end of the experience, the participants were directed to two different online Google questionnaires.

Subjects: Forty-one students have participated in the experiment and the 83% were men. 37 of the students were from different cities and towns of the Basque Country, 2 students were from Turkey and 2 students from Sweden. All the participants were computer science degree students.

Instrument: Two different Google Forms questionnaire were used to collect the user's experience in the evaluation. The first questionnaire has been used to collect information related to Wooclap and gamification (Table 2 and Table 3). The second questionnaire has been used to collect the data related to the WebQuests (Tables 4 and 5). The responses were collected on a 5-point Likert scale [30]. The reason for the use of 5-Point Likert Scale is that [1] conclude and consider it the most appropriate to use with students. The results have been limited to percentages. Through the analysis of these data, we have been able to obtain the tendency on the opinion of the students in each one of the questions in which they have been asked.

Data Analysis: Descriptive statistics were used to characterize the sample and to evaluate the participants' experience. Moreover, a Student's t test with a p-value of 0.05 was accomplished to confirm statistically the data collected. Results of this analysis are shown in all tables. The states that the average of the responses is higher than a value of 3, corresponding to a favorable level of motivation, importance or recommendation in the question evaluated.

4.2. RQ1: how can academic results be better?

Table 1 shows the number of students, the average mark of all students, and the number of students that did not pass each year. It is observable that during the 20/21 academic year, the control group had 32 students. They obtained an average grade of 5.22 and 12 of these students did not pass. On the other hand, during the 21/22 academic year, 41 students were enrolled in Software Engineering. The average grade was 6.06 and the number of failures was 9.

On the one hand, these data show an improvement of 0.84 in the average grade among students after applying gamification and Discovery Learning. This result confirms that both allow improving academic results among students. On the other hand, we have the number of failures. In the control group, 12 students failed out of 32 (37.5%) while in the other group, 9 students failed out of 41 (21.95%). This data shows that the number of failures was reduced by 15.55%, a percentage that reconfirms that gamification and Discovery Learning enhance academic results among students.

> The results confirm that the use of gamification and Discovery Learning improve academic results because the average grade has increased and the number of failures decreases.

Table 2
Results of the Wooclap Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

Questionnaire	Frequencies					Descriptive stats.		p-value
	SD	D	N	A	SA	Median	Mode	
Q1: I find Wooclap exciting, interesting and motivating.	0	0	5	19	17	A	A	0.000
Q2: I find Wooclap reveal the real students' competence.	2	10	11	15	3	N	A	0.001
Q3: I look forward to playing Wooclap.	0	0	6	28	7	A	A	0.000
Q4: I feel positive when playing Wooclap.	0	1	5	26	9	A	A	0.000
Q5: I like the collaboration & competitiveness in Wooclap sessions.	0	1	5	16	19	A	SA	0.001
Q6: Wooclap final leaderboard satisfies you.	1	5	12	12	11	A	A	0.086
Q7: I am eager to learn via Wooclap.	0	3	12	18	8	A	A	0.011
Q8: Wooclap feedback for questions is engaging.	1	4	9	23	4	A	A	0.005
Q9: Wooclap makes me study more to obtain a better mark in the game.	2	10	16	8	5	N	N	0.074

Table 3
Results of the Gamification Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

Questionnaire	Frequencies					Descriptive stats.		p-value
	SD	D	N	A	SA	Median	Mode	
Q1: The games made the learning environment a fun and engaging one.	0	0	5	24	12	A	A	0.003
Q2: The games motivated me to attend classes.	1	2	11	18	9	A	A	0.001
Q3: I was more motivated to study the course material every week in order to do well in the leaderboard for the games.	1	8	16	11	5	N	N	0.004
Q4: The total duration of the games was satisfactory.	0	1	8	20	12	A	A	0.013
Q5: The discussions about the correct and incorrect answers after every question were satisfying.	1	2	8	18	12	A	A	0.000
Q6: I believe that the games have improved my understanding of the covered topics.	0	1	6	26	8	A	A	0.000
Q7: Performing well in the games increased my self-confidence.	0	2	13	17	9	A	A	0.001
Q8: I would have prepared and engaged better if the game results were translated to actual marks for the module assessment.	1	4	14	12	10	A	N	0.009
Q9: I believe that the games have improved my analytical and problem-solving skills.	1	7	14	16	3	N	A	0.015
Q10: I wish gamification was used in other modules.	0	0	11	14	16	A	SA	0.001
Q11: I believe that gaming is a valuable use of instructional time.	0	0	2	19	20	A	SA	0.004
Q12: I do not found the use of the gamification intimidating.	0	3	7	14	17	A	SA	0.051

4.3. RQ2: why are the students motivated to play with Wooclap and with gamification?

Table 2 and Table 3 show the results to this research question. Figs. 2 and 3 show the results of the questionnaires visually. In Table 2, questions 1 to 6 show the students' opinion on whether Wooclap motivates them. Regarding Table 3, questions 1, 2, 4, 7 and questions 10 to 12 answer whether gamification motivates them.

Wooclap has been the platform used in class so that students could be more motivated and attentive during the theoretical classes. These classes are always more tedious for students, and they tend to stop attending. Table 2 shows that students find Wooclap exciting, interesting and motivating (Q1) as 36 of them (87.8%) said they agreed or strongly agreed with this statement. The vast majority of students (35, 85.36%) are looking forward to playing Wooclap again (Q3) and feel positive while they are playing Wooclap (Q4) (agree or strongly agree). The same is true for Q5, 35 of the students agree or strongly agree that they like the competitiveness that occurs in the Wooclap sessions. However, only 18 students (43.9%) agree or strongly agree that Wooclap reveals the real students' competence (Q2). They are also not very satisfied with the final leaderboard, as only 23 students (56.1%) agree or strongly agree with this question (Q6). Nonetheless, this is the only question in which the p-value is greater than 0.05 and therefore the only question in which the result is not significant. This means that in reality, students do not consider the final leaderboard satisfactory.

In relation to gamification (Table 3), students believe that the games make the learning environment fun and engaging (Q1, 36 agree or strongly agree, 87.8%). This makes students feel motivated to attend in class (Q2, 27 agree or strongly agree, 65.85%). For the students, the length of the game was adequate (Q4, 32 agree or strongly agree, 78.05%). For most of them, answering the questions well makes them increase their own confidence (Q7, 26 students agree or strongly agree, 63.41%). In the last block of questions (Q10, Q11, Q12), students agree or strongly agree that gamification is used in other subjects (30 students, 73.17%), that gaming is a valuable use of instructional time (39 students, 95.12%) and that gamification is not intimidating (31 students, 75.61%). For these 4 questions, the p-value is below 0.05, which shows that the results are statistically significant.

Results obtained by the p-value show that the results obtained are significant and validate the idea that gamification motivates students.

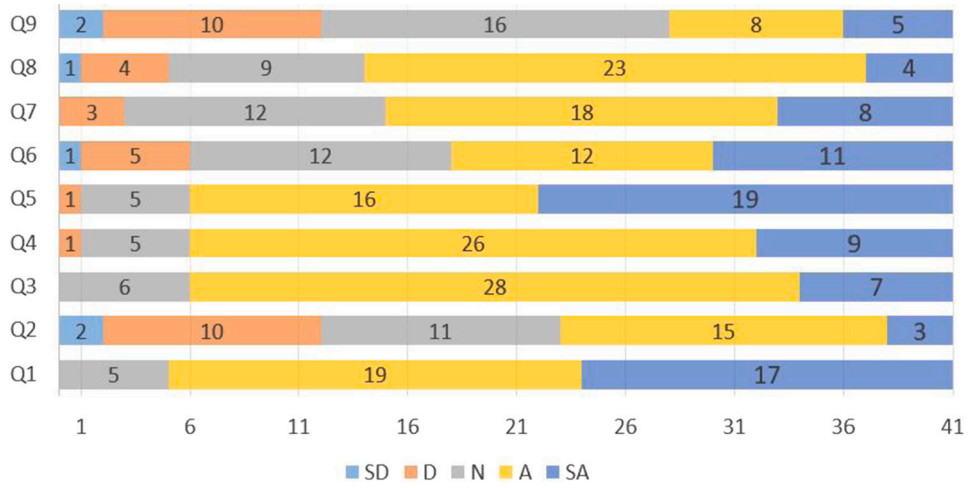

Fig. 2. Results of the Wooclap Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

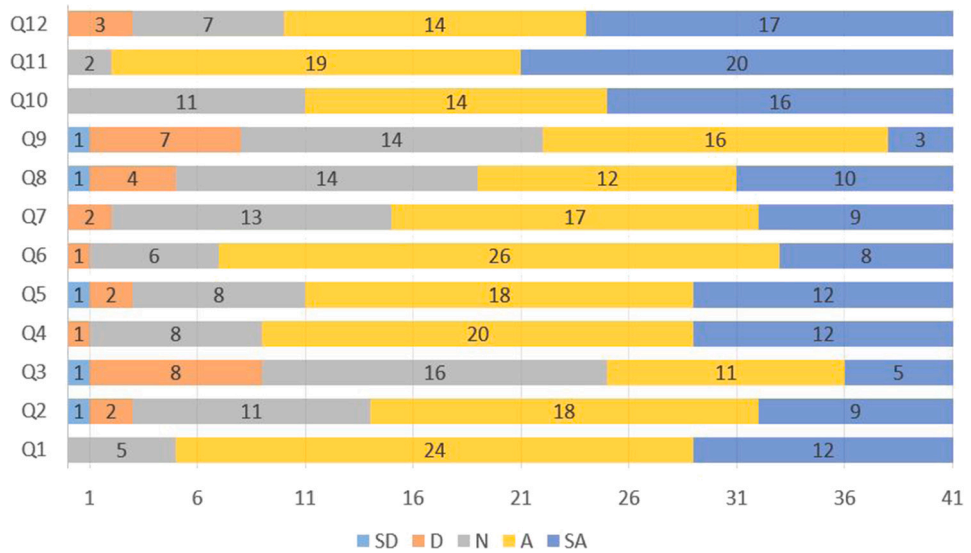

Fig. 3. Results of the Gamification Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

It can be concluded that students are more motivated in class because they have fun, they feel positive, and this makes them pay more attention in class. They want this practice to be used in other subjects as well.

4.4. RQ3: why does Wooclap and gamification make students study/learn more?

Table 2 and Table 3 show the results to this research question. Figs. 2 and 3 show the results of the questionnaires visually. In Table 2, questions 7 to 9 show whether students study or learn more thanks to Wooclap. Regarding Table 3, questions 3, 5, 6, 8 and 9 answer whether gamification makes students study or learn more.

Questions 7 and 8 of Table 2 refer to whether Wooclap makes students learn more. 26 students agree or strongly agree with learning through Wooclap (Q7, 63.14%) and 27 students believe that the lecturer's feedback to each question engages them (Q8, 65.85%). Q9 in Table 2 refers to whether students study more thanks to Wooclap to get better scores. Only 13 students (31.7%) agree or strongly agree with this statement. The p-value is greater than 0.05 for this last question, which means that it is not statistically significant.

Questions 3 and 8 of Table 3 refer to whether gamification makes students study more. Only 16 students (39.02%) agree or strongly agree that gamification makes them study more at home to get better results in the next game (Q3). Q8 answers whether students would study more if the results of the game were transferred to the final grade of the course. Only 22 students agree with this statement (53.66%). On the other hand, questions 5, 6 and 9 of Table 3 refer to whether students learn more thanks to gamification.

Table 4
Results of the level of participants' agreement about the steps of WebQuest projects Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA). (Introduction, I; Task, T; Process, P; Information Sources, IS; Evaluation, E; Conclusion, C).

	Questionnaire	Frequencies					Descriptive stats.		p-value
		SD	D	N	A	SA	Median	Mode	
I	Q1: Introduction presents goal of project.	0	2	8	26	5	A	A	0.003
	Q2: Topic of project is appealing.	2	3	7	21	8	A	A	0.000
	Q3: Introduction gives enough concrete information about the project.	0	5	11	17	8	A	A	0.006
	Q4: Project's scope is consistent with learning outcomes of the course.	0	4	6	24	7	A	A	0.000
T	Q5: In the task section, project expectations are clearly explained.	1	2	8	22	8	A	A	0.001
	Q6: Project requires interpreting knowledge in various forms.	0	5	6	24	6	A	A	0.000
	Q7: Developing a creative product is expected for completing the project.	0	4	5	25	7	A	A	0.014
	Q8: The roles and tasks within the project necessitate different points of view.	2	3	10	17	9	A	A	0.002
P	Q9: Stages of the process are organized so that they can be accomplished during the allocated time period.	0	3	9	23	6	A	A	0.004
	Q10: Each stage is explained in a clear and definite manner.	1	4	10	19	7	A	A	0.021
	Q11: Students can request help from the instructors when they face a problem during the process.	0	1	13	20	7	A	A	0.022
	Q12: Stages of the process are organized according to various levels of Blooms'taxonomy.	0	4	10	17	10	A	A	0.003
IS	Q13: Enough information is provided to complete the project.	0	4	10	14	13	A	A	0.001
	Q14: Web addresses are given with extra information that defined site.	0	6	10	16	9	A	A	0.005
	Q15: Information sources are consistent with project topic.	1	4	9	15	12	A	A	0.068
	Q16: Information sources are appropriate for target students.	0	3	7	21	10	A	A	0.004
E	Q17: Grading of each task was clearly defined.	3	1	8	17	12	A	A	0.091
	Q18: Grading was consistent with difficulty level of each task.	1	5	8	19	8	A	A	0.002
	Q19: Students have the chance to get feedback and performance reports.	2	2	7	17	13	A	A	0.019
	Q20: Evaluation criteria are consistent with course objectives in terms of information and skills.	0	5	6	21	9	A	A	0.003
C	Q21: Conclusion summarizes students' experiences during the process.	1	2	11	14	13	A	A	0.009
	Q22: Messages in conclusion aim to prepare students for real-life situations.	2	5	7	19	8	A	A	0.018
	Q23: Messages in conclusion give clear explanations to students about how they are expected to succeed when they finished the project.	2	4	10	16	9	A	A	0.021

Despite the fact that only 19 students agree or strongly agree that gamification improved their analytical and problem-solving skills (Q9, 46.34%), students confirm that they learn thanks to gamification. In Q5, 30 students (73.17%) agree or strongly agree that the feedback on each question helps them to learn. In Q6, 36 students (87.8%) confirm by agreeing or strongly agreeing that the games increase their understanding of the topics covered. In this case, all questions obtain statistically significant results. Question Q12 is the only one that obtains a result that is not statistically significant, but is not part of the questions that respond to this research question.

Results obtained by the p-value show that the results obtained are significant and validate the idea that gamification makes students learn more.

> Despite the fact that students do not study more at home to try to get better results in the games, they confirm that gamification helps them to learn. The feedback provided by the lecturer to each question also helps them to learn the concepts better.

4.5. RQ4: what is the level of participants' agreement about the steps of WebQuest project in terms of introduction, task, process, resources, evaluation, and conclusion?

Table 4 and Fig. 4 show the results of the survey about the Webquest's different sections. In this survey, students show their opinion regarding the structure of the WebQuests, their opinion about the introduction, task, process, information sources, evaluation and conclusions.

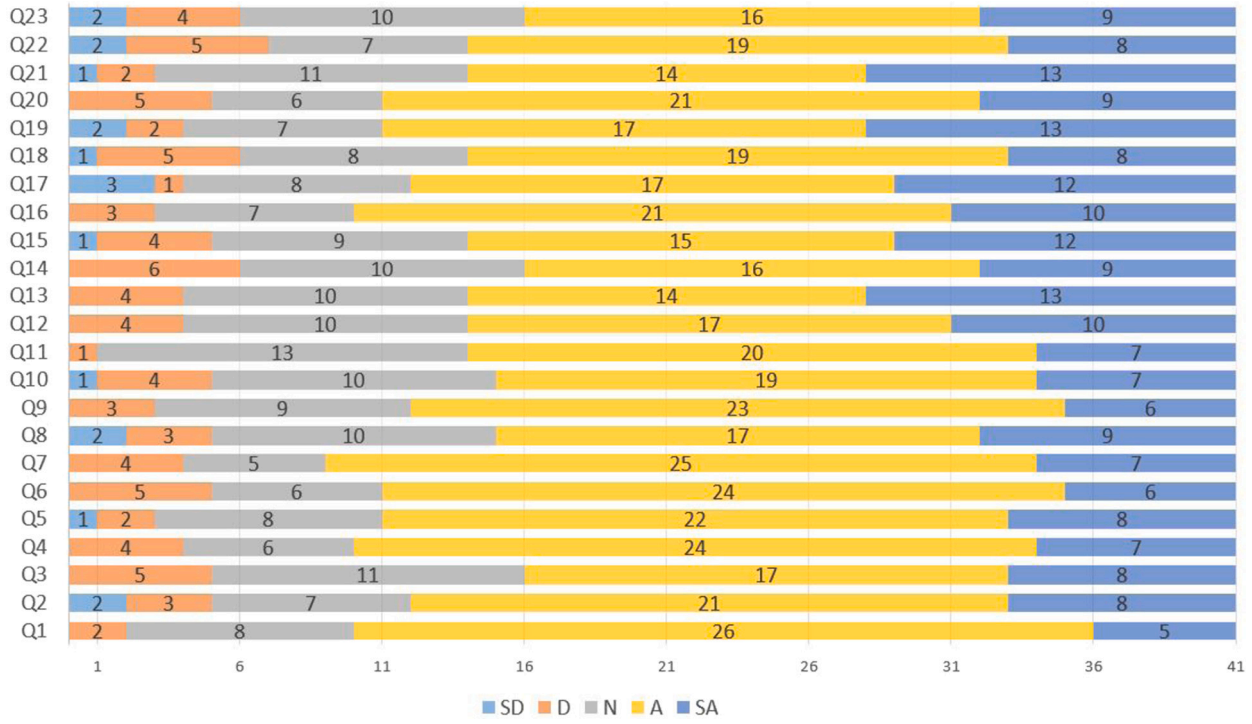

Fig. 4. Results of the level of participants' agreement about the steps of WebQuest projects Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

The introduction of the WebQuests is well rated by the students. The worst rated point is that students think that the introduction is appealing. This is a point to improve, but 29 students (70.73%) agree or strongly agree that the introductions to the WebQuests are sufficiently attractive. Students agree or strongly agree that the introduction shows the objectives of the project (31 students, 75.6%), the introduction gives enough information about the project (26 students, 63.41%) and that the scope is consistent with learning outcomes of the course (31 students, 75.6%).

Regarding the tasks, the worst rated is question 8 about the roles and tasks within the project necessitate different points of view. However, 26 students (63.41%) agree or strongly agree with this statement. For questions 5 and 6, 30 students (73.17%) agree or strongly agree that the tasks project expectations are clearly explained and project requires interpreting knowledge in various forms. For question 7, 32 students (78.05%) agree or strongly agree that a creative product is expected for completing the project.

The WebQuest processes have been very well rated, and it is not possible to highlight that one of the four questions has been rated worse than the others. In question 9, 29 students (70.73%) agree or strongly agree that stages of the process are organized so that they can be accomplished during the allocated time period. In question 10, 26 students (63.41%) agree or strongly agree that each stage is explained in a clear and definite manner. Finally, in questions 11 and 12, 27 students (65.85%) agree or strongly agree that students can request help from the instructors when they face a problem during the process and stages of the process are organized according to various levels of Blooms' taxonomy.

Regarding the sources of information, question 16 was the best rated by the students. In this question, 31 students (75.6%) agree or strongly agree that the sources of information are adequate for the students. In all other questions of this section 27 students (65.85%) agree or strongly agree that enough information is provided to complete the project, web addresses are given with extra information that defined site and information sources are consistent with project topic. Question 15 is the only one of this category in which the results show that the results are not statistically significant.

The evaluation has also been well valued by the students. To highlight question 20 in which 30 students (73.17%) agree or strongly agree that the evaluation criteria are consistent with course objectives in terms of information and skills. Likewise, 30 students agree with statement 19 that students have the chance to get feedback and performance reports. 27 students (65.85%) agree or strongly agree with statement 18 that grading was consistent with difficulty level of each task. Finally, 29 students (70.73%) agree or strongly agree that the grading of each task was clearly defined. However, this is the only question whose results are not statistically significant based on the results obtained by the p-value.

Finally, with respect to the conclusions, in all of them, 27 students (65.85%) agree or strongly agree with these statements: conclusion summarizes students' experiences during the process, messages in conclusion aim to prepare students for real-life situations and messages in conclusion give clear explanations to students about how they are expected to succeed when they finished the project.

Results obtained by the p-value show that the results obtained are significant and validate the good structuring of the WebQuests.

Table 5
Results of the perceptions of participants about WebQuests Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

Questionnaire	Frequencies					Descriptive stats.		p-value
	SD	D	N	A	SA	Median	Mode	
Q1: This project oriented me to research.	1	5	9	19	7	A	A	0.029
Q2: I did not have problems due to time limitations while completing the project.	0	5	8	16	12	A	A	0.002
Q3: I think I am suitable for group work.	0	1	3	15	22	A	SA	0.002
Q4: I did not need any help from the instructor during the project.	2	4	6	17	12	A	A	0.025
Q5: I valued the contribution of members of the WebQuest project.	1	5	11	13	11	A	A	0.034
Q6: I shared information with other participants.	2	3	8	15	13	A	A	0.139
Q7: I showed respect for other participants' opinions during the project.	0	2	5	16	18	A	SA	0.022
Q8: I generated creative ideas during the project	0	5	9	16	11	A	A	0.027
Q9: I helped other participants find their mistakes.	1	3	13	15	9	A	A	0.022
Q10: I completed the WebQuest project easily.	0	0	6	24	11	A	A	0.004
Q11: The WebQuest project encouraged me to collaborate with other participants.	1	6	6	17	11	A	A	0.023
Q12: The WebQuest project made me use my imagination.	2	3	11	17	8	A	A	0.047
Q13: WebQuest increased my skills in applying recently learned concepts to my profession.	1	3	9	22	6	A	A	0.046
Q14: Contributing to WebQuest increased my motivation in the course.	1	6	11	18	5	N	A	0.011
Q15: WebQuest supported my understanding of course-related topics.	0	1	12	16	12	A	A	0.001
Q16: WebQuest was effective for reaching the goals of the course.	0	1	11	20	9	A	A	0.000
Q17: I liked having web support for this course project.	0	6	7	16	12	A	A	0.003

Students value positively the different sections of the WebQuests provided in class to carry out their learning tasks. For all questions, most students agree with all of them.

4.6. RQ5: what are the perceptions of participants towards working with WebQuest projects in terms of planning skills, problems faced, implementation, real-life experience, popular and unpopular features, suggestions, and integration ideas?

To answer this research question, 17 questions were asked to the students. Most of the students think that the WebQuests guide them towards research (Q1, 63.41%). According to the answers to Q2, the students had no problems completing their assignments because of the time constraint (68.29%). The vast majority of students believe that they are suitable for group work (Q3, 90.24%). 70.73% of the students, state in Q4 that they did not need any help from the lecturer to complete their task. It is true that students asked few questions. They were able to find the necessary information on the Web to complete their assignments. Students agree or strongly agree in Q5 that they value the contribution of the WebQuest project members by 58.54%. 68.29% (28 students) agree or strongly agree with having helped other participants with their assignments (Q6). However, the p-value results show that the results are not significant and therefore, the students did not share information with the rest of the students. In Q7, 34 students (82.93%) defend that they respected the opinions of the other students. Most agree that they generated creative ideas during the project (Q8, 27 students, 65.85%) and 26 students (63.41%) agree that they helped other participants to find their mistakes (Q9).

Most students have completed the WebQuest project easily (Q10, 35 students, 85.36%). 28 students (68.29%) agree or strongly agree that the WebQuests encouraged them to collaborate with other students (Q11). 25 students (60.97%) believe that the WebQuests helped them use their imagination to complete the tasks (Q12). Similarly, 28 students (68.29%) agree or strongly agree that the WebQuests increased their abilities to complete assignments with newly learned concepts (Q13). Based on the responses in Q14, 23 students (56.1%) believe that the WebQuests contribute to increase their motivation about the course. WebQuests have helped 28 students (68.29%) to support their understanding of topics related to the course (Q15). 29 students (70.73%) agree or strongly agree that WebQuests are effective in achieving the course objectives (Q16). Finally, Q17 concludes that 28 students (68.29%) agree or strongly agree with having Web support to complete the course projects.

Summarizing, the contents of Table 5, students agree with all the questions posed to them except for Q14 whose mean value is neutral. The mode for all questions is also that students agree, except for Q3 and Q7, in which they strongly agree. Fig. 5 also shows that for all the questions, more than half of the students agree or strongly agree.

Results obtained by the p-value show that the results obtained are significant and validate that WebQuests enhance planning skills, problems faced, implementation, real-life experience, popular and unpopular features, suggestions, and integration ideas.

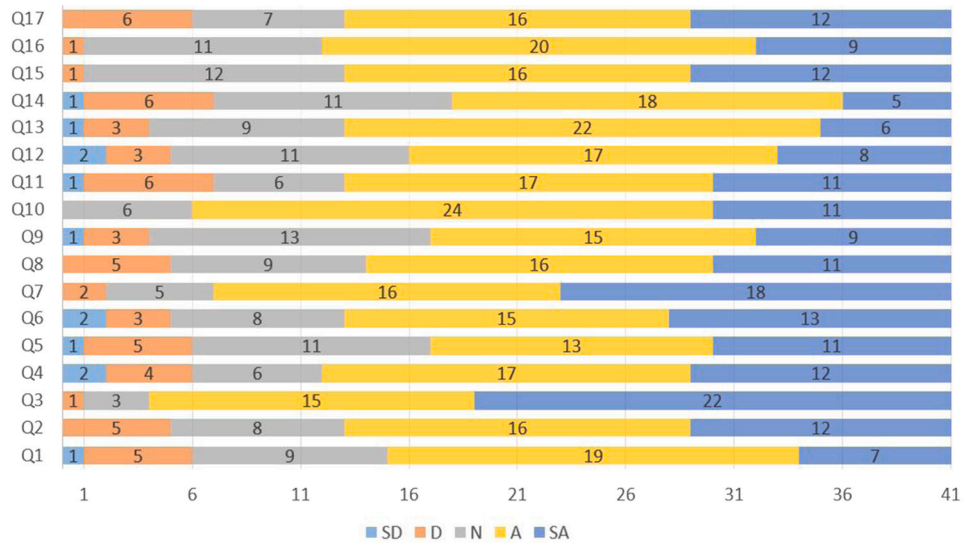

Fig. 5. Results of the perceptions of participants about WebQuests Survey (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA).

Students conclude that the WebQuests have helped them orient them to research, use their imagination, generate creative ideas, increase their ability to put what they have learned into practice, and even increase their motivation about the course. They have also improved their ability to work in groups, respecting the opinions of others and helping classmates from other groups to complete their homework. Likewise, it has meant that they do not need much help from the lecturer to complete their homework. Finally, the WebQuests have helped them to better understand what they have learned during the course.

4.7. Study limitations

The first of the limitations affects the number of students. It is considered that 41 students are an important and representative number without nonetheless, 37 of them belong to the same group, Basque Country citizens. The remaining 4 students are not a representative number to draw conclusions between students from the Basque Country and students from other countries. The study should be replicated in universities in different countries and check if the same results are obtained.

Another limitation focuses on the use of Wooclap for gamification. We considered that Wooclap was a suitable tool to gamify teaching sessions. However, we cannot know whether we would have obtained better or worse results using other tools such as Kahoot, Gimkit or Genially. It would be appropriate to repeat the experiment using one of these tools instead of Wooclap and see if the results are similar. Similarly, instead of using WebQuests to promote Discovery Learning in students, other mechanisms could be used and check if the results are similar.

5. Conclusions and future work

This paper presents the results of applying gamification and the Discovery Learning pedagogical approach in the subject of Software Engineering in the third year of the Computer Science degree. 41 students were involved during the 2021/2022 academic year. The experience was motivated by (i) the change on the part of the students in terms of information consumption, (ii) to improve the students' attention in the theoretical part of the subject and (iii) to motivate, improve the students' information search and research skills to solve their problems.

The experience has been evaluated with 2 different surveys: one on gamification and the other on WebQuests. The survey on gamification can be divided into two different parts: one on the tool used for gamification (Wooclap) and the other on the concept of gamification itself. Similarly, the survey on WebQuests can be divided into two parts: the students' opinion on the different sections of the WebQuests and their perception of the usefulness and improvements provided by the WebQuests. In addition, the academic results have been compared with a control group in the 2020/2021 academic year and the results obtained by applying gamification and Discovery Learning in the 2021/2022 academic year.

The results obtained combination gamification and Discovery Learning show that the marks obtained this last academic year have improved by 0.84 points compared to the previous one. With almost a third more students in the 2021/2022 academic year, the number of failures was reduced. The results show that the number of failures was reduced by 15.55%. The results also show that students are more motivated in class, they have fun, they feel positive and this makes them pay more attention in class. Results also show that Wooclap and gamification help students to learn. The feedback provided by the lecturer to each question also helps them

to learn the concepts better. Regarding the WebQuests, students value positively the different sections of the WebQuests provided in class to carry out their learning tasks. Finally, students conclude that the WebQuests have helped them orient them to research, use their imagination, generate creative ideas, increase their ability to put what they have learned into practice, and even increase their motivation about the course. They have also improved their ability to work in groups, respecting the opinions of others and helping classmates from other groups to complete their homework. The combination of gamification and Discovery Learning has improved results, skills and motivation that applying them only individually was not achieved.

In the future, it is desired that the entire Software Engineering course will use both techniques (gamification and Discovery learning instructional model). In addition, we want to use the Flipped Classroom pedagogical approach in the course by creating different videos with the theoretical aspects of the course. The student will watch these videos at home before attending the practical lesson. These videos can be gamified by including questions through tools such as Edpuzzle.[2] The Flipped Classroom instructional model uses a questionnaire at the beginning of the class that allows to know the knowledge of the students before starting the practical part of the subject [31,9,8]. In this way, it is intended that students can work longer in class and allow them to better acquire the necessary knowledge of the subject.

Declaration of competing interest

The authors report no potential conflict of interest.

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