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Improving Programming Learning in Engineering Students through Discovery Learning

Iñigo Aldalur y Xabier Sagarna

***Abstract*—Programming is basic to all engineering studies and a complicated subject for many first-year students. Many of the problems stem from the difficulty students have in finding the solution they need on the Internet, which makes students more dependent on the lecturer. Add to this the need for students to use new technologies in the classroom and the rapid digitization caused by the COVID-19 pandemic, the use of the Discovery Learning through WebQuests instructional model is of great help to students. For this subject, students are required to learn C programming using Visual Studio. The results show that WebQuests have contributed to improve academic results and skills such as teamwork, motivation and imagination to solve the problems posed. Students find themselves able to think of appropriate solutions, sometimes more than one solution, and carry them out. In addition, students conclude that the WebQuests have helped them to use their imagination, generate creative ideas and increase their ability to put what they have learned into practice.**

***Index Terms*—Discovery Learning, WebQuest, Engineering Programming**

I. Introduction

PROGRAMMING is a basic subject in all engineering degrees. This subject is not at all easy for students who, in general, must learn to think differently in order to learn to program. Students must learn the logic of programming, which is very different from what they have been using up to that point. Students have a hard time understanding programming structures, which makes it difficult for them to code and, therefore, to find and know how to use the structures needed to solve the problems they are faced with [1]. One of the problems of the students to solve their problems is that they are not able to find the necessary information on the network that can help them. Since at the beginning the reflection of what they should do is important and in many occasions they do not do it [2]. In addition, students often lack the habit of searching for this type of information on the net, and they also have a lack of motivation [3]. This problem of lack of problem-solving ability makes students need more help from the lecturer to solve their problems [4]. Some contributions have shown that lecturers who use appropriate methods in teaching programming, obtain better results [5]. Lecturers who have used different techniques to help students improve their programming skills. There are lecturers who have used visual programming languages to improve students' programming skills [6], gamification [7], Project Based Learning [8], Flipped Classroom [9] or Discovery Learning [10].

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In addition to all this, digitalization is bringing changes both in society in general and in education. Today's young people are digital natives and constantly consume information through their mobiles, tablets or computers. Universities are aware of this and are trying to use innovative pedagogical methodologies [11] [12]. In fact, there are contributions that affirm that the introduction of technology in education has benefits in the student collective from the point of view of motivation [13]. Through the Web, students can obtain and find the resources they need to learn to program. "WebQuest is a student-centered learning method that encourages students to learn from web-based environments, and instructors provide students with a list of related information to prevent them from accessing inappropriate sites." [10].

Discovery Learning is considered as a promising form of learning for several reasons. The main one being that the active involvement of the learner with the domain would result in a better structured knowledge base in the learner, as opposed to more traditional forms of learning, where knowledge is said to be simply transferred to the learner [14]. WebQuests are the main exponent of the Discovery Learning model of instruction [15]. WebQuests were created in the 1990s by two lecturers, Bernie Dodge and Tom March. Dodge was the initial developer of this tool, whose purpose was to develop students' ability to navigate the Internet with a clear objective: to learn to select and retrieve data from multiple sources and to develop critical thinking skills [16]. Critical thinking is a disciplinary process that proposes to analyze, synthesize and evaluate information, in such a way that knowledge is organized, arriving at a correct knowledge about a specific topic, being at the same time its objective to analyze or extract an idea based on observation, experience, reflection and reasoning coupled with communication [17]. The skill of critical thinking is fundamental to all software developers, and the goal is its improvement in the classroom. This is coupled with the fact that students have difficulties finding information on the Internet [18]. In addition, they must be creative to find a solution [19]. It is very common to receive emails from students with a programming problem whose answer is easily found with a simple search.

Furthermore, it should be added that the COVID-19 pandemic forced lecturers to teach their classes over the Internet overnight. This caused an overexertion on the part of the teaching staff to adapt their content to digital media. It also led to a lack of motivation and interaction on the part of the students. Although face-to-face classes returned the following year, this was only partially, with 2 days of online classes and 3 days of face-to-face classes. Coupled with the need for digitization of

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universities, student demand and possible confinements due to the pandemic, WebQuests can be a support in case of online or hybrid teaching. WebQuests can make students feel motivated and therefore attracted to the subject matter. However, it should be kept in mind that motivation is demonstrated by personal choice to participate in an activity and determines the intensity of effort and persistence in that activity.

In this context, this paper presents the experience of using WebQuests in the basic programming course in the degree of Renewable Energy Engineering. This experience has been carried out face-to-face (in first year students, classes have never been taught online during the pandemic, except during the confinement). The reception of this experience has been measured by answering the following research questions:

- RQ1: Does including Webquests improve academic results in programming?
- RQ2: What is the participants' level of satisfaction about the sections of the WebQuest projects in terms of introduction, task, process, resources, evaluation and conclusion?
- RQ3: What are the participants' perceptions towards working with WebQuest projects in terms of planning skills, problems faced, implementation, real-life experience, popular and unpopular features, suggestions and integration ideas?
- RQ4: What is the students' programming experience, steps taken before problem-solving, and reflection on problem-solving with the WebQuest activity?

The remainder of this document is structured as follows: Section II presents work related to the instructional model Discovery Learning through WebQuests. Section III presents the case study of this work, including the motivation and implementation of the initiative. The IV section describes the results obtained in the experience answering the research questions posed. Finally, section V presents the conclusions and future lines of action.

II. Related work

WebQuests have been widely used in the academic world. There are a large number of papers that have used them and studied their results, highlighting their benefits. Yang [20] 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 throughout the course. The WebQuests were implemented using the PHP programming language. To know the learning level of the students, at the end of the assignments the lecturers 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 greater satisfaction with the subject, computer skills, greater collaborative learning, reflection on learning and learning feedback. In the case of Chen [21], 188 undergraduate Business Administration students participated 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. Sousa et al. [22] present a work that aims to perform an analysis of the WebQuest methodology as an alternative to dynamize the class, causing a greater interaction of students during the application of computer contents, specifically Hardware and Software. The main results of the study show that the use of this methodological model allowed students to experience an innovative and stimulating learning, acquiring a theoretical knowledge integrated to practice. Zendler and Klein [23] 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 student body 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. [24] conducted an experiment with 65 second-year Educational Technology students. These students were divided into two groups, one being the control group. Seven WebQuests were developed and are hosted on the Zunal platform[1]. The objective was to work on the basic concepts of the Computer Networks subject. In addition, they wanted to develop the ability to compare things, organize data, summarize data, evaluate data, synthesize data, and be a better problem solver. The results show great results from the students being evaluated and seeing improvement in these skills.

All these experiences demonstrate the benefits of using WebQuests in the educational system. Students increase their motivation, participation and academic results. However, WebQuests are not perfect, and sometimes they have been used together with other active methodologies. The use of several learning techniques in the same subject is not the most common. Most of the papers present only one. Although it is difficult to find works that use gamification and Webquests, we can observe some [25], [26], [27]. Another example is Petroulis et al. [28]. They 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. However, gamification is not the only methodology that has been used in conjunction with WebQuests. For example, there are works that have used Project Based Learning (PBL) along with WebQuests [29], [30]. Chen [31] says that "the synergy of the Internet and PBL WebQuest optimizes higher-order thinking and problem-solving skills, fosters learner autonomy and motivation, and promotes the use of language for real-life purposes." Flipped Classroom (FC) methodology along with WebQuests has also been used [32], [33]. Samiei and Ebadi [34] compared a control group and a group using FC plus WebQuests with 20 students each. The goal was to give students more time in class to complete the tasks proposed in the WebQuests. Students were required to watch the videos and theoretical material before class. At the beginning, the knowledge acquired in class was evaluated in case any clarification or additional knowledge was needed. It is concluded that students in the control group

[1]http://zunal.com

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did fewer exercises. The academic results, however, were the same in both groups. Another methodology used along with WebQuests has been Mobile Learning that can bring a new learning experience to students and improve their learning skills. Chang et al. [35] conducted an experiment with 103 sixth grade students and divided into three groups: traditional classes, traditional classes with WebQuest, and outdoor WebQuest classes using the Mobile Learning methodology. The results of this study show that the use of outdoor WebQuest positively influences students' learning performance. In addition, when WebQuest was used in real-life situations, students were able to acquire more knowledge and experiences, and their critical thinking skills were fostered.

WebQuests have also been used to teach programming to students. Wang [10] used WebQuests to teach programming at 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 acquired the required knowledge. Tchutchulashvili [36] oriented his thesis to study the benefits of WebQuests in teaching the C programming language to students. Other objectives were to foster student autonomy and independence. The results showed that the students had many difficulties to be autonomous. They were not able to use or find easily accessible information to complete the tasks. However, the students found the experience interesting, although they felt lost on many occasions. Perrone and Clark [37] used WebQuests to teach their students how to program video games. The WebQuest described each and every step in creating a given video game (all the same). It also described the roles of the students: one was the programmer and the other the player. These roles kept changing. The results showed that the students were better able to acquire the necessary knowledge to develop video games. Lappas and Kritikos [38] created WebQuests to teach their students how to program in MATLAB. WebQuests are used in conjunction with the Inquiry-Based Learning methodology. The student body was divided into 3 different groups and each group was given a different task through a WebQuest. The results show that students were able to develop managerial skills (i.e., strategic and critical thinking, communication and conflict resolution through participation in group projects), presentation skills and computer programming skills, as well as solve complex numerical problems.

In all these experiences, the academic results obtained through the use of WebQuests have been equal or better. It can be concluded that the use of WebQuests helps students to obtain better results. In addition, other benefits obtained by the use of WebQuests have been described.

III. Case Study

The purpose of this section is to describe in detail the Discovery Learning instructional model, starting from the beginning and covering its different phases, as well as the methodology of each one of them. The experience has been developed in the Faculty of Engineering in the Renewable Energies degree. In the experience of the Basic Programming course, 28 first-year students participated, who will be considered as a control group, and another 30 students from the experimental group, who will use the Discovery Learning instructional model.

A. Beginning of the experience

All of us citizens were forced to be confined to our homes and teaching had to be delivered online overnight due to the COVID-19 pandemic. Due to this change, students were asking for the opportunity to learn through the use of new technologies. The choice of a methodology that allowed the use of new technologies was important. In addition, students need to develop information search skills on the web, as every programmer needs to search for solutions on the Internet. Students tend to question the lecturer easily in the face of any adversity. For this reason, the Discovery Learning instructional model fits the needs that were sought to be covered. For this purpose, different WebQuests have been implemented.

WebQuests not only allow for improved Web searching. Other main reasons are that a WebQuest is a scaffolded learning structure that uses links to essential resources on the Internet and a way to motivate student inquiry through a central, open-ended question, the development of individual expertise, and participation in a final group process that attempts to transform newly acquired information into more sophisticated understanding. The best WebQuests do this in ways that inspire students to see richer thematic relationships, facilitate a contribution to the real world of learning, and reflect on their own metacognitive processes [16].

The 2020/2021 and 2021/2022 academic years have been the same at Mondragon Unibertsitatea. During both years, first year students have been studying on-site, always maintaining safety distances, masks and ventilation. Whenever a student tested positive, they had to stay at home and keep up with their academic obligations as long as the illness allowed them to do so. Likewise, students confined to close contacts were to remain at home and keep up with their academic obligations. In order to be able to conduct face-to-face classes, during the summer of 2020, larger classrooms were adapted to be able to conduct face-to-face classes and maintain safety distances. For this reason, some laboratories were converted into classrooms and vice versa. This was possible because the number of students per classroom at Mondragon Unibertsitatea is not very high.

The first year students are 18 and 19 years old. Most of these students are from the Donostialdea region, that is, people who live near San Sebastian, Spain. Most of the students come from upper-middle class families. The number of women during the 2020/2021 academic year was 10 (35.7%) and 5 during the 2021/2022 academic year (16.66%). Each student attends class

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with his or her own laptop. Upon enrollment, students receive instructions on the minimum computer requirements for the entire degree program. The first week of the course, students are assisted by university staff to install all the software required for the first academic year.

Fig. 1. The research design and study procedure

B. *Description of the experience*

The design of the course has taken into account the different topics that complete it. This course consists of 4 topics: basic instructions, functions, arrays and strings. In order to treat each of the topics of the course independently, 8 WebQuests have been created. The basic instructions can be divided into 5: if, for, while, do-while and switch instructions. During the first week, students learn the if statement through a WebQuest. The second WebQuest is designed to learn the for statement, and this is carried out during the next two weeks. The third WebQuest is also used for two weeks to learn the while statement. The sixth week is devoted to the do-while instruction, and there is a fourth WebQuest designed for this task. Finally, the seventh week, they learn the switch instruction through another WebQuest. These five WebQuests to learn the basic instructions account for 27% of the final grade. The topics of functions and arrays account for 33% of the final grade and are developed during 4 weeks by means of a WebQuest each. Finally, strings are learned during the last 2 weeks and account for 40% of the final grade. Figure 1 shows the WebQuests created for each topic and the time students spent on each of them. For this topic, students are required to learn how to program in C (version C18) and Visual Studio 2019 (version 16.2) is used for this purpose.

The sections of each WebQuest can be divided as follows (see Figure 2, WebQuest on arrays):

- Introduction: a brief description of the topic to be worked on is provided. In addition, a brief example or some basic instruction (by means of an image and its description) of the concept that the students must learn is provided.
- Tasks: in this section are included the tasks to be performed by the students. The lecturers provided the students with information about the expected results of each of the exercises.
- Process and resources: both sections are merged into one. The exercises are divided into levels of difficulty. In addition, the first task is always developed individually. This first task is to learn how to use the new programming concept. If all students did not learn its use correctly, it would be impossible to perform the following group tasks. The group tasks are performed in groups of 3. The selected tasks are ordered by their difficulty. Within each group task, the necessary resources are provided with information to help students solve the most common problems. For this purpose, links to the necessary resources or videos with important information are provided. If students need additional information, they should look it up on the web.
- Evaluation: the evaluation provides a base of test cases that corroborate that the functions developed by the students are correct. These test cases contemplate all possible cases of the tasks that the students must fulfill, and the students execute them manually. The evaluation also provides the score obtained by the students based on the number of test cases that work.
- Conclusions: the conclusions summarize the knowledge gained.

At the end of the course, the students answered a questionnaire to try to answer the research questions RQ2, RQ3 and RQ4 posed at the beginning of the semester. For this purpose, after the last exam of the course, all students were gathered in the classroom and answered the questionnaire and the results were kept anonymously. The questionnaire was presented by the same lecturers of the subject before notifying the results and answers of the final exam. The students still had the possibility to take the resit exam despite having failed the exam. For the evaluation, the results obtained the previous year by the students who took the course in the traditional way (RQ1) were taken into account. In this course (2020/2021) the WebQuests and digital material were not included. The classes were face-to-face, and the faculty offered theoretical and practical classes. In the practical classes, the concepts to be learned by the students were presented. In the practical classes, students had to perform a series of exercises individually. If the students had doubts or problems, they turned to the faculty to solve them. At the end, the lecturer corrected all the exercises of the session. The process was significantly different from the WebQuests.

On the other hand, the lecturer for both courses were the same in all subjects. This makes it fair to compare the results of both academic years, since there has been no other change for the students.

IV. Results

This section shows the main results obtained by the student collective in the 2020/2021 and 2021/2022 academic years and from the surveys carried out to gather the students' opinions, followed by an analysis of each of the research questions. The questions in Tables II and III, we have taken as a basis from Gulbahar's work [39]. For the Table IV, we have taken as a basis the work of Wang [10]. Responses were collected on a Likert scale [40].

A. *RQ1: Does including Webquests improve academic results in programming?*

Table I shows the academic results of the student collective in the academic years 2020/2021 (left) and 2021/2022 (right).

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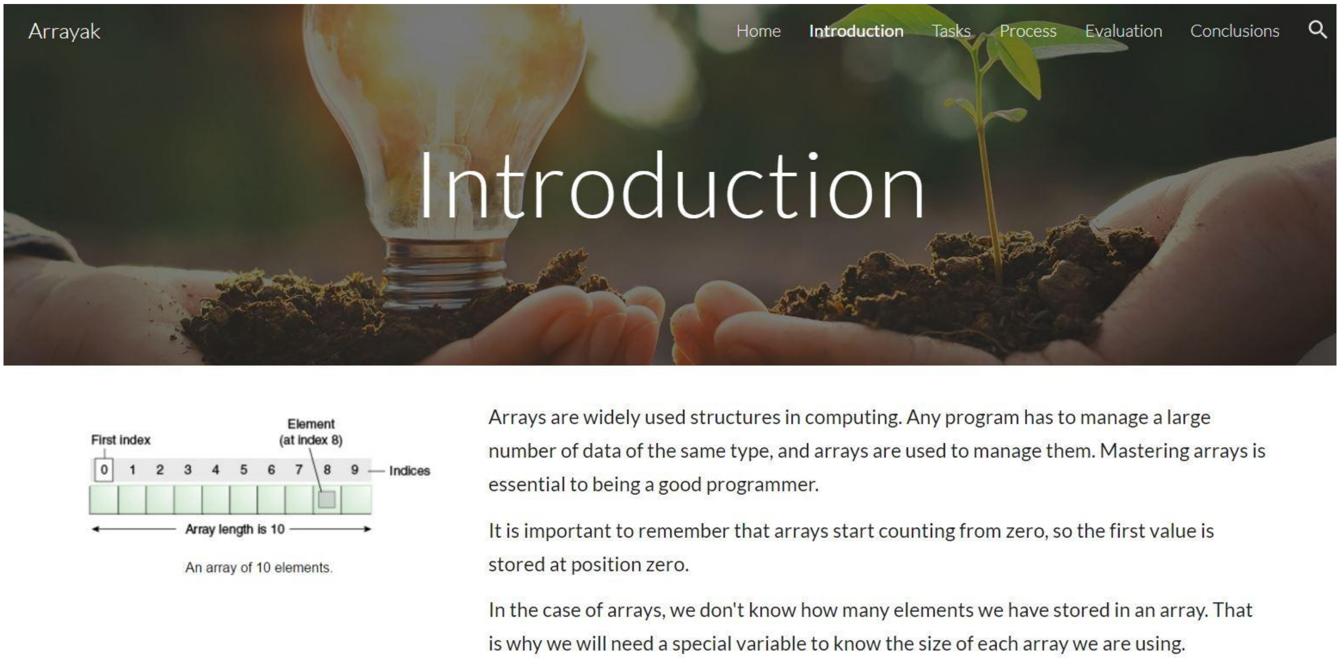

Fig. 2. WebQuest about Arrays

TABLE I
ACADEMIC RESULTS OF THE STUDENT BODY FOR THE 2020/2021 AND 2021/2022 COURSES

	2020/2021				2021/2022					
Subject	#Students	Mark AVG	#Fails	St. D.	#Students	Mark AVG	#Fails	St. D.	Cohen V.	ES
Programming	28	6,49	4	2,59	30	6,46	5	2,79	0,01	0
Math	29	5,82	5	2,98	31	4,75	15	2,89	0,36	0,18
Physics	29	6,1	4	2,12	31	5,21	10	2,03	0,42	0,21
Technical drawing	27	6,24	1	2,44	30	5,87	7	2,85	0,14	0,07
Base metodológica	26	7,55	0	2,25	30	6,67	0	2,63	0,36	0,18

In both academic years, the number of students per subject, the average grade obtained by students in each subject and the number of failures are shown. It can be seen that the number of students in both years is practically the same. It is important to mention that the teaching staff has been the same in all subjects in both academic years.

Observing the academic results of programming obtained by the students in the two courses, we can see that they are the same. However, if we look at the results of the rest of the subjects, we can see that the academic results are substantially worse and that the number of failures is considerably higher. The academic results in the subjects of mathematics, physics and methodological basis have decreased between 0.88 and 1.07 points. This decrease is very large and shows that the students of the 2021/2022 academic year had a lower level than the students of the 2020/2021 academic year. The smallest decrease in the grade was in technical drawing, with a decrease of 0.37 points. If we look at the number of failures, methodological basis is the only subject that no student failed in the two academic years. This subject is the easiest of the course and the one in which students always obtain the best academic results. However, in mathematics, physics and technical drawing the number of failures has increased significantly (200% in mathematics, 150% in physics and 600% in technical drawing), while in programming the increase was only 25%.

The fifth and ninth columns of Table I show the standard deviations for the 2020/2021 and 2021/2022 academic years, respectively. The values shown for each subject are similar and show that there are no significant differences.

The last two columns of Table I show us the Cohen's Value and the Effect Size (ES) [41]. When the ES value is less than 0.5, it is considered to be small. In Table I it can be seen that all ES values are less than 0.5 and there are even values less than 0.2, which can be considered very small [41].

Conclusions: Although the use of WebQuests does not reflect an improvement in the academic results of programming, if we compare these academic results of both courses with the rest of the subjects of the semester, the results have been superior. Therefore, it can be concluded that WebQuests have helped students to obtain better academic results.

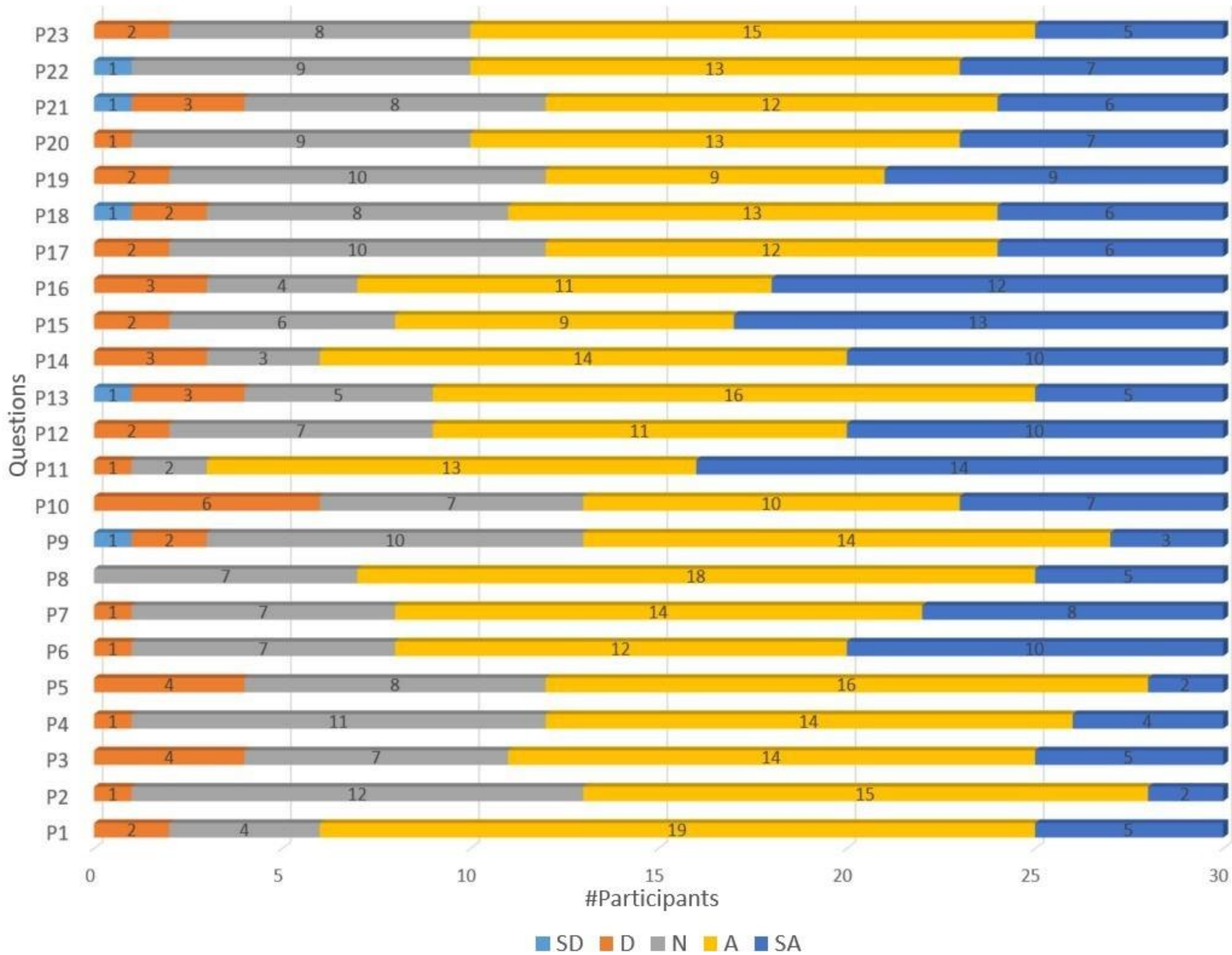

Fig. 3. Results of the participants on whether they agree on the sections of the WebQuest projects (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

B. RQ2: What is the participants' level of satisfaction about the sections of the WebQuest projects in terms of introduction, task, process, resources, evaluation and conclusion?

Table II and Figure 3 show the students' opinion about the structure of the WebQuests and the information that each section provides them to achieve the objectives.

As for the introduction (see block I in Table II), students are in favor of the information it provides. The most voted option for each of the statements was agree. Students agree that the introduction presents the objectives of the project, that the topic is engaging, that it provides concrete information about the project, and that the scope is consistent with the learning objectives of the course.

The tasks (see block T in Table II) obtained very similar results to those of the introduction. The most voted option in each of the statements has been to agree. In spite of having good results, statement 5 obtained a slightly lower rating than the rest of the statements. Improvements for the next course would be to better explain the expectations of the project. Students strongly agree with statement 6 regarding that projects require interpreting knowledge in a variety of ways. Students agree that a creative product is expected to be developed to complete the project, and that roles and tasks within the project require different points of view.

In relation to the processes (see block P in Table II), the students have voted very positively to the questions, with the exception of statement 9. The results of statement 9 are good, but there was a group of students who had difficulties completing the tasks in the set time. This may be the main reason why this statement had slightly lower results. Students agree that the steps have been explained clearly. Statements 11 and 12 have obtained very good results. In fact, for statement 11 there are more students strongly agreeing than agreeing. Lecturers have been accessible at all times to help students solve their problems, and the tasks are organized according to Bloom's taxonomy.

The sources of information (see IS block in Table II) provided to the students have been very well valued by them. Despite the good results, one student disagrees that sufficient information was provided to complete the project. Students

TABLE II

RESULTS OF THE PARTICIPANTS ON WHETHER THEY AGREE ON THE SECTIONS OF THE WEBQUEST PROJECTS (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)

	Questions	Frequer ies				
		SD	D	N	A	SA
I	Q1: The introduction presents the objective of the project.	0	2	4	19	5
	Q2: The theme of the project is attractive.	0	1	12	15	2
	Q3: The introduction provides enough information about the project.	0	4	7	14	5
	Q4: The scope of the project is consistent with the learning outcomes of the course.	0	1	11	14	4
T	Q5: In the tasks section, the expectations of the project are clearly explained.	0	4	8	16	2
	Q6: The project requires interpreting knowledge in various ways.	0	1	7	12	10
	Q7: It is expected to develop a creative product to complete the project.	0	1	7	14	8
	Q8: Project roles and tasks require different points of view.	0	0	7	18	5
P	Q9: Process steps are organized so that they can be accomplished within the allotted period of time.	1	2	10	14	3
	Q10: Each stage is explained in a clear and defined way.	0	6	7	10	7
	Q11: Students can ask lecturers for help when they face a problem during the process.	0	1	2	13	14
	Q12: The stages of the process are organized according to the different levels of Bloom's taxonomy.	0	2	7	11	10
IS	Q13: Sufficient information is provided to complete the project.	1	3	5	16	5
	Q14: Web addresses are provided as additional information.	0	3	3	14	10
	Q15: The sources of information are consistent with the theme of the project.	0	2	6	9	13
	Q16: The sources of information are appropriate for the students to whom they are directed.	0	3	4	11	12
E	Q17: The grade for each task was clearly defined.	0	2	10	12	6
	Q18: The rating was consistent with the level of difficulty of each task.	1	2	8	13	6
	Q19: Students have the opportunity to receive feedback and performance reports.	0	2	10	9	9
	Q20: The evaluation criteria are consistent with the objectives of the course in terms of information and skills.	0	1	9	13	7
C	Q21: The conclusion summarizes the experiences of the students during the process.	1	3	8	12	6
	Q22: The conclusion messages are intended to prepare students for real life situations.	1	0	9	13	7
	Q23: Messages at the conclusion give students clear explanations of how they are expected to succeed when they finish the project.	0	2	8	15	5

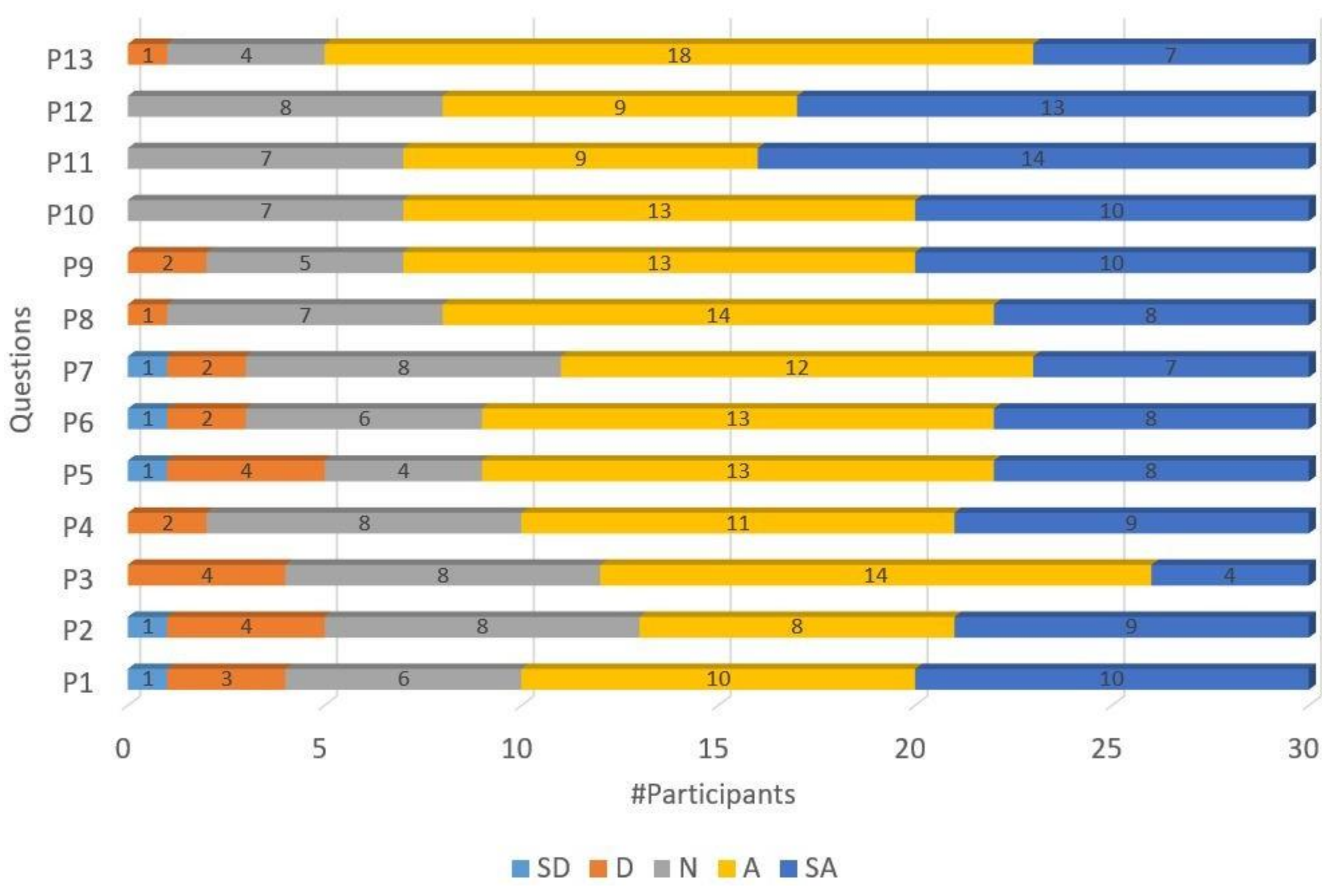

Fig. 4. Results of the survey on student perceptions of the WebQuests (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

TABLE III
RESULTS OF THE SURVEY ON STUDENT PERCEPTIONS OF THE WEBQUESTS (STRONGLY DISAGREE, SD; DISAGREE, D; NEITHER AGREE NOR DISAGREE, N; AGREE, A; STRONGLY AGREE, SA).

Questions	Frequencie				
	SD	D	N	A	SA
Q1: I value the contribution of the members of the WebQuest project.	1	3	6	10	10
Q2: I have shared information with other participants.	1	4	8	8	9
Q3: I have shown respect for the opinions of other participants during the project.	0	4	8	14	4
Q4: I had creative ideas during the project	0	2	8	11	9
Q5: I helped other participants to find their mistakes.	1	4	4	13	8
Q6: I completed the WebQuest project easily.	1	2	6	13	8
Q7: The WebQuest project encouraged me to collaborate with other participants.	1	2	8	12	7
Q8: The WebQuest project made me use my imagination.	0	1	7	14	8
Q9: The WebQuest increased my ability to apply newly learned concepts to my profession.	0	2	5	13	10
Q10: Contributing to the WebQuest increased my motivation in the course.	0	0	7	13	10
Q11: The WebQuest helped me understand the topics related to the course.	0	0	7	9	14
Q12: The WebQuest was effective in achieving the objectives of the course.	0	0	8	9	13
Q13: I liked having web support to complete these course projects.	0	1	4	18	7

agree that web addresses with extra information have been provided, this information was also consistent with the task to be completed and adequate. In fact, for the latter (statements 15 and 16) there are more students strongly agree than agree.

As in the previous sections, the evaluation (see block E in Table II) also obtained good results. Statement 19 is the one with the most varied results. It is the only statement in which the neutral vote has been most used by the student body. However, it is also the one with the highest number of agreement votes in this section. In the rest of the statements, there are no significant differences, with the agreement vote being the most used. Students agree that the grading for each assignment was clearly defined, the grading was consistent with the level of difficulty of each assignment, and the evaluation criteria are consistent with the course objectives in terms of information and skills.

Finally, the conclusions (see block C in Table II) are the only section with two strongly disagreeing votes. However, the results are good, as the majority of the student body agrees with the statements in this section. The conclusions summarize the student body's experience during the project, give them a hint about real-life situations in programming, and give them the correct and necessary expectations for when they finish the project.

Cronbach's alpha describes to what extent all items in a test measure the same concept and is therefore related to the interrelation of the items within the test [42]. In our case, the Cronbach's alpha value is 0.91 for the results of Table II. A value of 0.9 or higher indicates an excellent result [42].

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

C. RQ3: What are the participants' perceptions towards working with WebQuest projects in terms of planning skills, problems faced, implementation, real-life experience, popular and unpopular features, suggestions and integration ideas?

Table III and Figure 4 show the results of this research question. For most of these questions, the majority of the votes have been for agree or strongly agree. The first 8 questions had the worst results overall, despite the majority of the student body agreeing or strongly agreeing. Question 2 is the only one in this group in which more students strongly agreed with sharing information with other participants. In the rest of the questions, the majority agreed with positively valuing the contributions of other members, respecting their opinions, helping other participants to solve their mistakes, completing the tasks with ease, using their imagination, and having creative ideas during the project. In addition, they believe that WebQuests are suitable for collaborating with other participants.

In the questions from question 9 onwards, we can observe how very few students disagree and that the number of votes in agreement is higher. The students positively believe that the WebQuests helped them to improve their programming skills, as well as to increase their motivation. Not only that, but they appreciate the fact that they have the support of the web during the project they are carrying out. Students strongly agree that the WebQuests help them to better understand the course content, and that they are a useful tool to achieve the course objectives.

The Cronbach's alpha value for Table III is 0.84. For values between 0.8 and 0.9 it is considered a good result [42].

Conclusion: Students conclude that the WebQuests have helped them to 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 in other groups to complete their assignments. Finally, students strongly agree that the WebQuests help them to better understand the course content and that they are a useful tool to achieve the course objectives.

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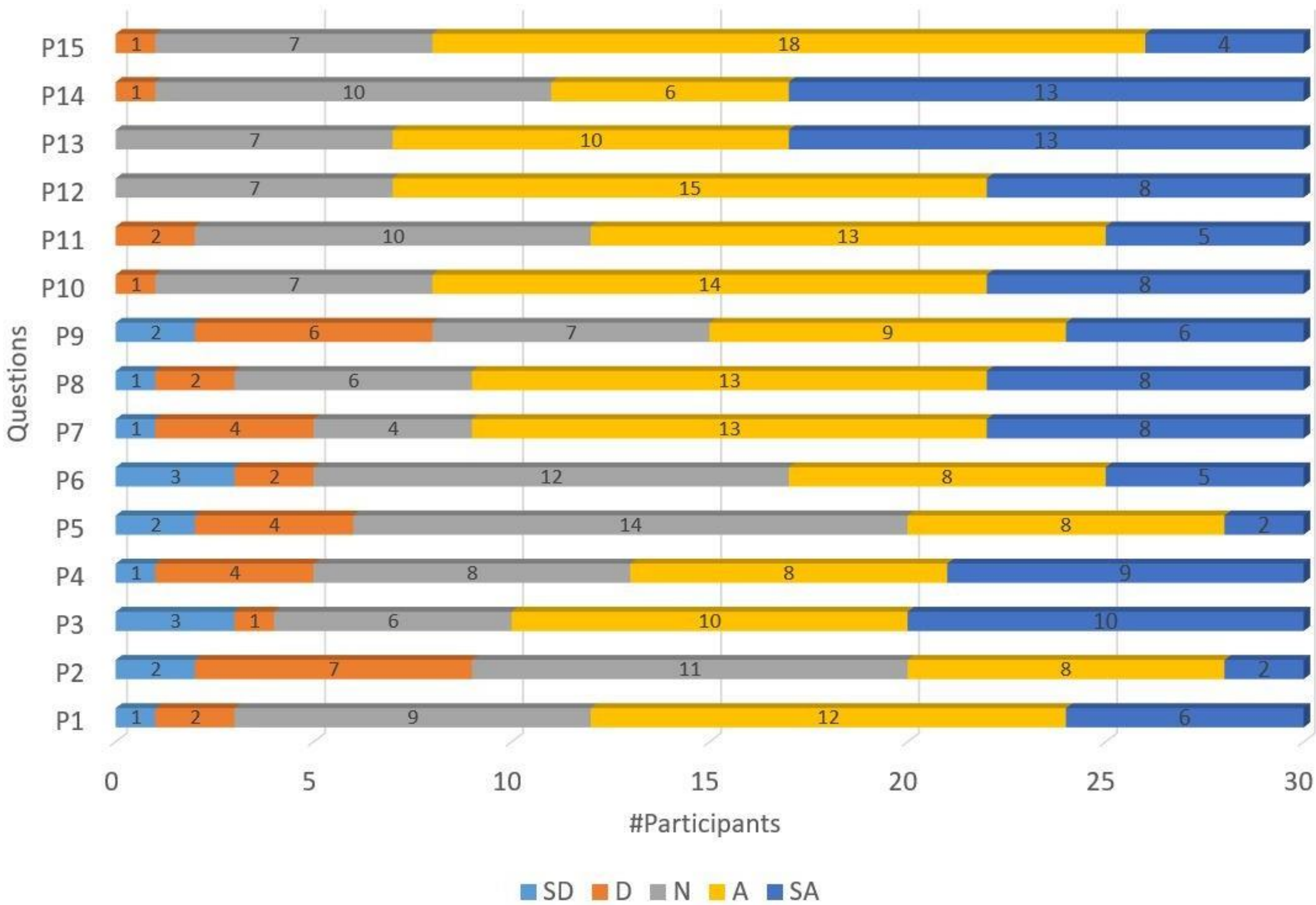

Fig. 5. Student results on whether WebQuests help them learn to program (Strongly disagree, SD; Disagree, D; Neither agree nor disagree, N; Agree, A; Strongly agree, SA)

TABLE IV

STUDENT RESULTS ON WHETHER WEBQUESTS HELP THEM LEARN TO PROGRAM (STRONGLY DISAGREE, SD; DISAGREE, D; NEITHER AGREE NOR DISAGREE, N; AGREE, A; STRONGLY AGREE, SA). (PROGRAMMING EXPERIENCE, PE; STEPS BEFORE PROBLEM-SOLVING, SBPS; REFLECTION ON PROBLEM-SOLVING, RPS)

	Questions	Frequencies				
		SD	D	N	A	SA
PE	Q1: I had different ways and methods to solve programming problems.	0	1	3	18	8
	Q2: I thought I was capable of dealing with programming problems.	1	3	8	12	6
	Q3: I was satisfied with the process of how I solved the programming problems.	1	4	4	13	8
	Q4: I tried to use the resources to solve the programming problems I encountered.	0	0	7	11	12
	Q5: I have confidence to face various programming problems.	1	4	6	10	9
SBPS	Q6: When solving programming problems, I will think about how the problem came about.	1	2	8	16	3
	Q7: When solving programming problems, I will think about different aspects to find the solution to the problems.	0	4	7	10	9
	Q8: When solving programming problems, I will try to find more than one solution.	1	3	3	14	9
	Q9: When solving the programming problems, I will reflect on the way in which the classmates formulated the questions.	0	0	7	18	5
	Q10: Before I start solving the problems, I will think if the method I have used can solve the problems.	0	5	5	12	8
RPS	Q11: I am able to follow the method I have thought of to solve programming problems.	1	2	10	14	3
	Q12: I will adopt a step-by-step process to overcome scheduling issues.	0	5	8	11	6
	Q13: After using the method I have created to solve the programming problems, I will think if the problems have been solved with the method.	0	3	3	13	11
	Q14: If the scheduling issues remain unresolved, I will look for another method to resolve the issues.	0	0	5	11	14
	Q15: If the programming problems remain unresolved, I will do a self-reflection to find out the reasons.	0	1	5	13	11

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D. RQ4: What is the students' programming experience, steps taken before problem-solving, and reflection on problem-solving with the WebQuest activity?

To answer this research question, we divided the questions in Table IV into 3 blocks: Programming Experience (PE), Steps Before Problem-Solving (SBPS), and Reflection on Problem-Solving (RPS) with the WebQuest activities. Figure 5 shows all the results.

Regarding PE (see PE block in Table IV), all statements have the majority of votes in agreement, except statement 4 where the majority strongly agrees. From this, it can be concluded that the programming experience of the student body has been excellent. The students have seen different ways of solving programming problems and, therefore, they see themselves capable of dealing with these problems. The students feel satisfied with how they have solved the problems they have faced and are confident enough to tackle various programming problems. Moreover, most of them have used various resources to solve the problems they have faced.

Regarding the steps before facing a problem (see SBPS block in Table IV), most students agree with these statements. The majority of the student body felt that they think about how the errors could have occurred. In addition, most of them think of different ways to solve the problem and try to find more than one solution. In general, most think about how their peers have solved the problem and whether the method they use is adequate to solve the problem.

Finally, Reflection on Problem-Solving (see RPS block in Table IV) was highly rated by the students. Most agreed with statements 11, 12, and 13 and strongly agreed with statements 14 and 15. Students believe that they were able to follow the correct method to solve the problem, to adopt a step-by-step process to overcome programming problems, and to reflect on whether the method they devised could solve the problem. On the other hand, most students strongly agree that they will find a solution to the problems they did not solve and that they are able to self-reflect to find the solution.

The Cronbach's alpha value for Table III is 0.83, so in this case it is also considered a good result [42].

Conclusion: The students rate very positively their ability to deal with the programming problems they face. They see themselves able to think of appropriate solutions, sometimes more than one solution, and carry them out.

E. Threats to validity

The first limitation concerns the number of students. It can be considered that 28 and 30 students are a valid number for the evaluation, however, all of them belong to the same group, citizens of the Basque Country. The study should be replicated in universities in different countries or different Spanish autonomous communities and verify if the same results are obtained.

The second would be related to the COVID-19 pandemic. The second and third year students had classes in hybrid format during the 2020/2021 academic year. However, first-year students have always had face-to-face format at our university in both the 2020/2021 and 2021/2022 academic years. The largest classrooms at the university were taken so that the student body maintained safe distances, and masks and ventilation were mandatory. Positive or confined students were provided with material and exercises at home. In case of 3 positives, the classes would be given online, however, this never happened. If explanations were needed, they were given upon return to the classroom. The students of the 2020/2021 academic year were involved in a situation never seen before, and the personal relationships in the classroom were affected. During the 2021/2022 academic year, students had already experienced this situation the previous year in the baccalaureate, with less impact. These situations may have had an impact on academic results.

Finally, the fact that the subject lecturers present the questionnaire to the students may have an impact on the students' answers. To avoid a greater impact, the questionnaire was answered before obtaining the grade and seeing the results, in addition to having the resit exam available. However, students who knew that the exam was not passed could have answered the questionnaire with lower scores. On the contrary, students who perceived that they had passed could have responded with higher values.

V. CONCLUSIONS AND FUTURE WORK

This paper presents the results of the application of Discovery Learning through WebQuests in the basic programming course of the renewable energy engineering degree. The experience was motivated by the change on the part of the students in terms of information consumption, and to motivate and improve the students' information search and research skills to solve their problems.

The results of all the subjects of the 2021/2022 semester have been compared with the control group of the same semester of the 2020/2021 academic year. In addition, the experience has been evaluated with different surveys: (i) the students' opinion about the different sections of the WebQuests (ii) their perception of the usefulness and improvements brought by the WebQuests and (iii) the students' perception of their programming skills through the WebQuests.

The results obtained in the basic programming subject do not show any improvement, but in the rest of the subjects of the semester the results have worsened considerably. Therefore, it can be concluded that the WebQuests have helped, to some extent, to improve academic results. For the students, the WebQuests were well-structured, as each of the sections has helped them to complete the assignments and successfully achieve the course objectives. In addition, students conclude that the WebQuests have helped them to 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 in other groups to complete their assignments. Students strongly agree that the WebQuests help them to better understand the course content, and that they are a useful tool to achieve the course objectives. Finally, students rate very positively their ability to deal with the programming problems they are given. They see themselves able to think of appropriate solutions, sometimes more than one solution, and to carry them out.

In the future, it would be interesting to include the Flipped Classroom instructional model, since this pedagogical method would allow us to have more class hours so that students could better complete the designed tasks. New tasks could also be included to reinforce the knowledge needed in the subject. This pedagogical model allows students to acquire the theoretical knowledge at home and, consequently, there is more time for other tasks in class. The videos provided to the students to acquire the theoretical knowledge could be gamified, which could increase students' motivation to watch the videos at home.

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