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Development of ICT-Based Didactic Interventions for Learning Sustainability Content: Cognitive and Affective Analysis

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Abstract: Information and Communication Technologies (ICT) have been recognized as innovative resources for improving the teaching–learning process. The aim of this study was to design and validate ICT-based learning interventions for sustainability content from a cognitive and affective perspective. Specifically, didactic resources based on a discovery learning model, such as WebQuest and video games, have been used. The research design was of a quasi-experimental type with three groups of students who were given pre-test and post-test questionnaires. The sample was made up of 81 secondary school students, selected by means of non-probability sampling. The cognitive, behavioral, attitudinal, and emotional variables of the students were measured according to the teaching methodologies used. As a measurement instrument, a questionnaire was designed, composed of several blocks in relation to the variables under study. The results obtained reveal that ICT has a positive influence on the academic progress experienced by students, with the students who used video games obtaining better results than those who used WebQuest. The didactic interventions did not modify the attitude or the environmental behavior of the students regardless of the methodology used. Regarding emotions, it was observed that didactic interventions with ICT positively affected the emotions experienced by the students and contributed to fighting boredom.

Keywords: ICT; sustainability; secondary education; video games; WebQuest; affective domain; cognitive domain; environmental awareness

1. Introduction

In recent years, we have been facing one of the most important environmental challenges for society, the planetary emergency announced by various global institutions [1,2]. Throughout these years, there have been numerous experiences of different research teams involved in this field of knowledge who are convinced of the need for the educational sector to play an essential role in the formation of a responsible citizenship. Educational institutions have begun to show some interest in relevant changes or turning points, especially once the United Nations indicated that environmental change is a global connection [3,4]. However, several studies have shown that responses to these calls for action are insufficient. They also point out that the urgent global emergency we are facing requires a redoubling of efforts and initiatives from the context of science education to involve citizens in building a sustainable future [5]. Specifically, it should be noted that, although the concept of sustainable development has been integrated into the educational curriculum of different countries as compulsory learning content [6–8], several studies indicate that school approaches should include a community program for the improvement of environmental education [9]. Despite the fact that schools

often have limitations in implementing such programs, a science, technology, society, and environment education (STSE) can promote literacy in the field of sustainability [10] because it contributes to the acquisition of knowledge and concepts that will enable citizens to solve problems in the field of science and technology and to create positive and critical attitudes towards sustainable development [6,11,12]. However, cognitive aspects are related to affective aspects in the teaching and learning processes in all areas of education, including the teaching of science [13,14]. Therefore, education for sustainability must consider not only an improvement in knowledge, but also in the attitudes and behavior of students in this area [6]. For our line of research, referring to attitudes that predict environmental behavior, some of the studies carried out in this regard are worth mentioning. Various authors [15] agree that people only behave in an environmentally responsible way when they are sufficiently informed about environmental problems, are motivated to do so, and, furthermore, can generate qualitative changes. Other studies show that thinking and behaving pro-environmentally not only benefits the environment, but also leads to greater emotional well-being [16]. Other studies [17] indicate that in order to assess an attitude it is necessary to consider factors that are inherent to it, such as scientific knowledge, disposition, and behavior. In addition, certain studies, such as the 2015 study by Abramovich and Loria [18], reveal that sustainability education courses are an appropriate means of increasing the environmental awareness of science and technology teachers and have the potential to promote responsible and environmentally friendly behavior, even in the long term. However, it should be noted that some authors question whether scientific knowledge leads to improved environmental behavior. Specifically, Kollmuss and Agyeman [19] do not attribute a direct relationship between environmental knowledge and pro-environmental behavior. These studies indicate that it is not possible to explain in detail what leads a person to act in a pro-environmental way because it is a highly complex issue, although it is true that economic, social, and cultural factors have some influence. Arnold, Cohen, and Warner indicate that educational programs focused on promoting sustainability have less effect on students' pro-environmental attitudes than simply observing sustainable attitudes in the immediate environment at home [20]. Also, research by Kuhlemeier, Van den Bergh, & Lagerweij [21] indicates that out of a sample of 9000 secondary school students, 57% showed very positive attitudes towards the environment despite students' limited knowledge of environmental issues.

Despite the importance of science for contemporary society, students experience negative attitudes towards it [22]. In fact, several authors have observed that, as the level of education increases, attitudes towards science become increasingly unfavorable [23]. In addition, educational institutions do not adapt as quickly to the new educational needs of young people [24], generating a great deal of demotivation in students that results in low academic performance [25]. These attitudes seem to worsen with age, with the origin being in the last years of primary education and worsening in secondary education [26,27]. Some studies indicate that the lack of experimental work or the lack of connection of scientific content with the daily life of students may be partly responsible for this lack of interest among students [28]. Therefore, in order to improve student results and attitudes, several studies indicate that it is necessary to promote the use of active methodologies in the classroom [29]. Some studies indicate that students are bored in teacher-centered classes, and, conversely, they enjoy the more participatory classes [30]. Along these lines, there are methods that change the way students work, allowing for more active participation. These are appropriate for science education in secondary schools [31]. They are likely to have a positive effect on students' attitudes towards science, offering better results than the typical expository method [32]. Therefore, it is necessary that the teacher selects new educational resources for the classroom that are appropriate to the new needs of the students, achieving good development of the teaching–learning process. There is evidence that learning can be improved by adjusting the teaching style to an individual student's learning style [33,34]. Therefore, teaching actions must consider the differences in the way students approach learning, with the aim of being able to adjust their action plan and thus optimize the learning of all students [35]. In this sense, the use of active teaching strategies is particularly relevant because they offer opportunities to all students, regardless of their learning style, and respect individual differences. Therefore, it is

essential for future teachers to be trained in active methodologies and guided in the search for teaching styles that provide them with the necessary mechanisms to be a true agent of change, and in turn, empower them to interact within a multicultural and changing space [36].

In line with previous studies, it is worth highlighting the importance of technology and its influence on the educational environment. As some studies point out [37], education has been influenced by technology, which has directly changed the way people interact, communicate, study, and research. Thus, technology has become an agent that provides opportunities for innovation in education [38]. International interest in technology and education offers an interesting opportunity to investigate the complex relationships between curricular standards, course design, classroom practices, technological improvements, and student learning. To a certain extent, technological means call for a new configuration of the teaching and methodological process that has been traditionally used in our centers, where the development of knowledge does not have to fall completely upon the teacher, and the student's function is not merely to receive information [39]. For example, the use of Information and Communication Technologies (ICT) in education could awaken the interest of students and teachers in scientific research. In this way, an improvement in creative, communicative, and collaborative skills could be made possible, allowing access to a greater amount of information and providing the means for the better integral development of individuals [40]. For this reason, ICT have been recognized as innovative resources because they make it possible to consider numerous teaching strategies that are capable of promoting significant learning [41,42]. Consequently, ICT have become an increasingly indispensable tool in educational institutions where they can perform multiple functions. Technology can enhance scientific and technological literacy, allowing teachers and students to gain experience with the ideas and skills essential for future personal and professional success [43]. In addition, the use of technology to create learning environments has led to the development of more interactive and engaging environments [44]. However, the use of ICT in education is becoming a reality that forces education systems to take positions towards it. Specifically, rapid technological advances also challenge those who are developing innovations for teaching [43].

Considering the relevance of ICT in the educational field, it is worth highlighting some tools with great educational potential. For example, WebQuests are an inquiry-oriented activity, in which some or all the information with which students interact comes from the Internet [45–47]. That is why it is located within the tools of ICT and is developed around the elaboration of answers to problematic questions. The key idea that characterizes a WebQuest is that it is built around an attractive and achievable task that involves some high-level cognitive skills [48]. The development of this implies creative thinking and includes problem solving, critical judgments, analysis, and synthesis [49].

In addition, some research [50] indicates that a necessary factor for successful learning is motivation, and that this could be achieved through other ICT tools such as video games [51]. Studies indicate that video games have appeared in our society in the field of leisure [52]. These studies highlight that 80% of adolescents use them. Numerous studies indicate that video games can be included as an educational resource in the classroom by placing them within the framework of ICT [38,40]. Over the years, research has recognized that video games have great potential from an educational point of view [53,54]. Specifically, there is research indicating that video games are not as negative as originally assumed, highlighting some aspects that may be quite positive [55]. Huizinga [56], in his theory of games, considered them to be a fundamental element in the intellectual development and socialization of the individual. The authors of [57] consider that video games train cognitive skills such as deduction, recognition of visual models, hierarchical structuring of priorities, and rapid decision making. Specifically, some studies [58] conclude that, in addition to the expected results in terms of motivation, video games as an educational strategy generate positive effects on attendance, punctuality, and other socio-affective variables such as self-esteem, collaboration, and interaction among students. Thus, for example, some studies [59] propose an experience for working on auditory perception content in the primary school classroom using specific software. Apart from learning, the children using the software had a more favorable attitude towards the task proposed than those in the control group,

and teacher–student interaction was favored, becoming more relaxed and casual. With respect to science teaching, several studies indicate that video games allow a deep understanding of the complex scientific vocabulary and phenomena that are unobtainable in traditional science classrooms [60].

Various studies [61–63] indicate that the use of video games or simulators in the social sciences does not promote good academic results, and, in the best of cases, these results are equal to those obtained with traditional methodologies. On the other hand, these studies reveal that, in mathematics, physics, and other subjects where objectives can be set, this type of teaching strategy can be used successfully. Although video games present a wide range of possibilities as a resource for teaching educational content, becoming very useful tools for teaching, there are authors [64] who have identified some problems for the use of video games in the classroom. These include the lack of time for teachers to learn to use these tools, the large amount of irrelevant content and information that may be contained in a video game, or the equipment problems in many schools that may not have modern computers or the necessary hardware to run some of these video games [65]. Other research addresses issues related to the abusive use of video games by leaving other activities unattended, such as studying or even socializing with family and peers [66].

On the other hand, there are several studies on video games that indicate the possible influence of the gender variable on their use [67]. The gender variable has been shown to be a factor to be considered when verifying whether there are important differences according to gender in the choice of university careers [26,68,69]. Focusing on computer science, for example, some authors [70] found that the disproportion in these university studies in favor of men is significant. Furthermore, personal interests would also be influenced by gender, with girls more interested in health-related issues, while boys would prefer some physics-related subjects [28].

The need to design and implement active methodologies to foster positive attitudes towards science in secondary school students is acknowledged by many authors, as stated above. Different investigations in the field of science education [71,72], determine that learning is much more meaningful and efficient in cases where students are an active part of the learning process. In this sense, video games become a potentially useful educational resource in science classes. Considering that young people today are the main consumers of video games, it is interesting to take advantage of this resource to develop habits in students related to communication, commitment, fun, or motivation towards science [73]. However, integrating video games into the classroom may not be easy for the teacher or even applicable to all contexts, although, as some authors [51] indicate, their use could have a very positive effect on motivation, interest, and retention. In general, students tend to be more interested in activities involving games than in other traditional activities, and retention is improved by using simulators. In this sense, the authors of [74] identified some variables that could affect the effectiveness of video games, such as personality, gender, academic skills, or the ability to play video games. In this sense, other research [75] suggests that video games should be complemented with meta-cognitive activities that remind students that the main objective of the game is learning. This is because, according to these authors, students did not think that the game used was a learning experience and associated it with a merely recreational activity. Therefore, they found that sometimes the students ignored important mechanics for learning; so in this sense, when using this type of tool measures should be taken to try to guide the students' learning. Thus, although according to some authors video games provide a rich and productive learning environment [76], other research [77] points out that most educational video games have been developed with a greater emphasis on the educational aspect than on the recreational one, losing their effectiveness because they neglect fun and immersion in their design.

Based on these approaches, it is worth highlighting the need for more research on this resource, since more in-depth study is needed on the influence of video games on student learning in different subjects. To this end, as noted by the authors of [76], it is possible that, if the characteristics of the game are appropriately adjusted to the educational content, it will ensure the commitment of students and achieve the desired learning results. Likewise, as mentioned above, most studies on video games have

referred to variables related to student learning; however, no research has been found referring to the affective and attitudinal domain of students who use video games as a teaching resource. Therefore, the research problem that guided this work was: do educational interventions based on ICT resources such as video games or WebQuests have a positive influence on aspects related to the cognitive, affective, and attitudinal domain of the students who use them?

In line with the previous background, this research uses ICT to develop educational interventions on sustainability content. The purpose of the study was to analyze the influence of the use of WebQuest and video games on both the cognitive and affective domains of the participating students; that is, to analyze whether the inclusion of didactic ICT resources improves the learning of secondary education students and whether it contributes to forge sustainable behaviors and attitudes, as well as positive emotions in the students. Therefore, this research is in line with the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 [2] which integrate and balance three essential dimensions of sustainable development, namely economic, social, and environmental, providing a valuable roadmap for articulating global policy-making and achieving sustainability [78]. However, if these goals are to be achieved, or, at least, progress made, there must be real changes in attitudes and behavior [79]. Education is one of the most important issues in achieving the goal of sustainable development for all [2].

2. Materials and Methods

The design of the research was experimental with three groups of students who were given, pre-test, and post-test questionnaires. The variables under study referred to aspects related to the cognitive dimension and the affective dimension. For the development of the didactic interventions, three active didactic strategies based on the ICT were selected with the purpose of analyzing the influence of these methodologies on the different selected variables. Specifically, a didactic intervention was designed by integrating the use of two video games and a WebQuest for the teaching of some sustainability concepts. The teaching methodology used in the classroom was considered as an independent variable and the dependent variables were the level of knowledge achieved by students, environmental awareness, attitudes and environmental behavior, emotions, and gender.

2.1. Objectives

The general objective of this work was to develop ICT-based didactic interventions for the learning of sustainability contents, from a cognitive and affective perspective. In this sense, the research carried out aimed to study the influence of the use of video games and WebQuest on the different variables under study. Specifically, it measured whether video games and WebQuest influenced, on the one hand, the level of knowledge reached by secondary education students, and, on the other hand, whether they had an impact on the variables referring to the attitudinal and affective domains. In other words, the study measured whether the emotions experienced by students were modified or not after the development of the different didactic interventions or whether improvements were produced in the environmental awareness, attitudes, or environmental behavior of the participating students. Likewise, the use of video games and WebQuest was analyzed according to the gender variable.

Based on these considerations, the general objective was broken down into the following specific objectives:

- Specific objective 1 (SO1): To diagnose students' attitudes and preferences regarding science, computer science, and video games.
- Specific objective 2 (SO2): To analyze the variable level of knowledge of the students according to different didactic methodologies based on the use of ICT.
- Specific objective 3 (SO3): To analyze the variables related to the environmental behavior of students according to different teaching methodologies based on the use of ICT.

- Specific objective 4 (SO4): To analyze the variables related to the environmental attitude of students according to different teaching methodologies based on the use of ICT.
- Specific objective 5 (SO5): To analyze the emotional variables of the students according to different teaching methodologies based on the use of ICT.
- Specific objective 6 (SO6): To analyze the students' preferences towards computers and video games, distinguishing by gender.
- Specific objective 7 (SO7): To check how the students valued the different didactic interventions and their own learning after the intervention.

2.2. Hypotheses

The above specific objectives served as the basis for the following working hypotheses:

- Hypothesis 1 (H1): The use of ICT-based active methodologies improves the level of knowledge of secondary school students in relation to sustainability concepts.
- Hypothesis 2 (H2): There are no statistically significant differences in the use of video games versus the use of WebQuest for learning concepts related to sustainability.
- Hypothesis 3 (H3): The use of ICT-based active methodologies promotes environmental behavior in students.
- Hypothesis 4 (H4): The use of ICT-based active methodologies promotes an increase in the level of sustainable attitudes among secondary school students.
- Hypothesis 5 (H5): Secondary school students show different emotions depending on the ICT methodology used in the classroom.
- Hypothesis 6 (H6): The participating students value positively the intervention carried out in the classroom, regardless of the ICT activity implemented.
- Hypothesis 7 (H7): There are differences in the preferences for computers and video games according to the gender of the participating students.

2.3. Sample

The sample was selected by means of non-probabilistic convenience sampling due to the ease of access in a collaborating educational center. Specifically, it was made up of 81 students aged 14–16 years old. These students were divided into three working groups. Group A consisted of 28 students, group B of 27 students, and group C of 26 students. The tutor of all three groups was consulted on their academic performance and indicated that group C was significantly underperforming compared to the other two groups, which will be considered in the analysis of the study results. Regarding the gender distribution in the groups, in groups A and B the number of male and female students was approximately the same. Group A had 53.6% male students compared to 46.4% of female students. Group B had 44.4% male and 55.6% female students. In the case of group C, the female gender predominated, and comprised 76.9% of students. Table 1 shows the distribution of each group according to the gender variable.

Table 1. Distribution of the sample by groups and gender.

	Male		**Female**	
	%	***n***	**%**	***n***
Group A (n = 28)	53.6	15	46.4	13
Group B (n = 27)	44.4	12	55.6	15
Group C (n = 26)	23.1	6	76.9	20

The didactic intervention carried out was developed during three sessions. Firstly, all the groups had an introductory session where the work to be done and the general contents under study were explained in a theoretical way. Afterwards, the different didactic interventions based on a model of

learning by discovery guided by ICT were carried out. Specifically, with group A, a WebQuest was designed and implemented that worked on the object of study. This activity consisted of a series of questions and some websites that the learners, divided into groups, had to use as a source to answer different questions [80]. Group B used the video game *My Green Energy Planet*, following the guidelines of a study [81] in which a complete assessment was made of various online video games related to climate change. After evaluating the authors' analysis and making an exhaustive review of the video game, it was selected as an educational resource for teaching content related to energy and sustainability. With this video game, the students in group B had to manage a city by implementing saving measures, creating renewable energy production plants, and eliminating non-renewable energy plants. Group C used the video game *Control of the Spanish Network* created by the institution Red Eléctrica de España (Spanish Electricity Network). This game, due to its mechanics and approach, was very suitable for working on concepts in the classroom based on a sequence of small tests. As in group B, the students had a worksheet to guide them in the use of the video game that also listed questions to work on during the game. This worksheet included a description of the activity, the objectives of the game, detailed instructions for the game, and a questionnaire to focus the students' attention during the game. The questions posed for the sessions with video games were the same as those posed to the group that played the WebQuest, since both activities were designed to work on the same concepts.

Finally, it should be noted that in all groups the participating teacher was the students' usual teacher in order to minimize the impact of possible unknown variables that could affect the results. In addition, special care was taken to ensure that timing was respected, so that each group spent the same amount of time on each of the proposed activities. During the development of the intervention, cognitive, behavioral, attitudinal, and emotional variables were measured in order to assess academic progress, the emotions experienced during the performance of the different activities, and the behavior and the attitude of the students towards the environment.

2.4. Measuring Instrument

To collect the information, the measuring instrument used was a questionnaire composed of several blocks:

- Block 0 (Personal data): This was composed of 11 questions about the students and their preferences.
- Block 1 (Knowledge): This block aimed to measure the variable level of knowledge of the students. It consisted of 20 multiple choice questions with four possible answers, with only one being correct. The questions were structured around three blocks. One on sustainability (8 questions), another on renewable energies (6 questions), and a third block on saving measures (6 questions). In the case of the questions related to saving measures, it should be noted that there could be several good answers, with the correct one being the most important or the one providing the most benefits, so this detail was communicated to the students.
- Block 2 (Environmental behavior): The instrument proposed to measure the ecological behavior was based on the Ecological Behavior Scale [82]. Since this is quite extensive and deals with many issues, it was decided to keep only those questions related to energy, adding three questions that would establish some correlations with the questionnaire. It consisted of nine Likert-type questions that were adapted to a five-point scale to give the complete questionnaire a certain uniformity and make it easier for the students to answer the questions related to this study variable. The possible answers were: 1 (never), 2 (rarely), 3 (sometimes), 4 (often), and 5 (always).
- Block 3 (Environmental attitude): The questionnaire used to measure this variable was based on the Spanish translation of the Environmental Concern Scale of [83] carried out by the authors of [84]. However, we decided to eliminate some of the questions, leaving only those that were more related to the content worked on. It consisted of nine five-point Likert questions with the options: 1 (strongly disagree), 2 (disagree), 3 (neither agree nor disagree), 4 (agree), and 5 (strongly agree).

- Block 4 (Self-evaluation): A block was included in the questionnaire for the students to evaluate the activities carried out, as well as their own learning after the development of the didactic interventions. This block was composed of eight questions to be answered by means of a Likert type scale that ranged from 1 (totally disagree) to 5 (totally agree), so that the students could evaluate the experience.
- Block 5 (Emotions): A total of five positive emotions (joy, satisfaction, surprise, fun, and confidence) and five negative emotions (boredom, fear, nervousness, concern, and anxiety) were selected to be evaluated by means of a Likert type scale with four points: 1 (I have not felt it), 2 (I have felt it on some occasions), 3 (I have felt it quite a few times), and 4 (I have felt it at all times). The idea was to measure the emotions felt by the students in each of the work sessions for the different groups. Some of the emotions selected (joy, satisfaction, or boredom) were representative of the way in which video games are played according to the authors of [85], and were associated with some of the faces of the Premo© (Product Emotion Measurement Instrument) used by these authors to create the EMODIANA (EMO-Dartboard), an app for measuring emotions. The objective behind including these faces in the questionnaire was to offer the student reinforcement when correctly relating the emotion felt with that requested in the questionnaire. In addition to these representative emotions, fun, worry, confidence, and anxiety were added, so that there would be the same number of positive and negative emotions [22,27,86].

Tables 2–5 show some examples of the questionnaire questions in the different blocks:

Table 2. Example of the knowledge questions in the questionnaire (block 1).

1. What is sustainable development?	
(a)	It is that which allows the economy to be maintained at sustainable levels over time without fluctuations of relevance.
(b)	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
(c)	Development in which progress does not imply the exhaustion of non-renewable resources by establishing more conservative policies for their management.
(d)	It is that which guarantees the well-being of citizens through the creation of quality employment and wages appropriate to the population's standard of living over time.
4. Mark, from the following options, which one is among the principles of sustainable development:	
(a)	Ensuring the stability of the economy over time.
(b)	Reduce and eliminate unsustainable patterns of production and consumption.
(c)	Encourage dialogue and cooperation with other countries around us.
(d)	All answers are correct.
14. At present, renewable energies could not guarantee electricity supply and will always need support from other energy sources:	
(a)	False. Renewable energies produce a constant flow of energy.
(b)	True. Renewable energies can be influenced by external factors such as weather conditions.
(c)	False. Although they can be influenced by external factors such as weather conditions, the power grid stores surplus energy for when it is needed.
(d)	True. Because the energy from these energy sources will never be enough on its own to meet the demand.
20. To reduce the environmental impact of our cities we can:	
(a)	Place plants in windows and balconies to improve air renewal.
(b)	Keep the streets clean by throwing trash into bins and containers.
(c)	Use public transportation whenever possible as an alternative to private transportation.
(d)	None of the answers are correct.

Table 3. Example of the environmental behavior questions in the questionnaire (block 2).

1. When I'm at home, I leave the lights on in places where they're not needed.
5. When I open the fridge, I avoid keeping the door open so I don't waste a lot of energy.
8. If the heating is on, I keep the windows closed to prevent the room from getting cold.

Table 4. Example of the environmental attitude questions in the questionnaire (block 3).

3. Pollution does not personally affect my life.
5. Even if public transport were more efficient than it is, I'd still take the car to work.
9. Lessons on the conservation of natural resources should be taught in public schools.

Table 5. Example of the self-evaluation questions in the questionnaire (block 4).

1. I liked the way the theoretical introduction to the subject was presented.
4. The activity carried out in the second session seemed to me to be short.
7. I think I've learned about sustainability and renewables.

The questionnaire was implemented at two different times. The first time pre-test, and later post-test. The pre-test questionnaire was answered by the students before the first session and had the purpose of measuring all the variables before the intervention. This questionnaire also contained the block of personal data that would only be requested at this time. The post-test questionnaire was answered by the students after finishing the different didactic interventions and had the purpose of measuring all the variables immediately after the intervention.

In order to validate the designed questionnaire and show whether it was reliable and had adequate discriminatory power, the methodology recommended by Ding and Beichner [87] was followed. Firstly, the results referring to validity and reliability were presented based on the analyses recommended by other studies by Ding and Hershberger, Ding et al., and McColgan et al. [88–90]. Regarding the validity of the instrument, it was considered valid if what is measured was related to the objective of the test and the specific domain of the contents measured in the study. Validity was determined by consensus of opinions from a group of teachers who are experts in the subject matter of the study. Thus, a draft of the designed test was passed on to a group of expert teachers, with the aim of checking whether the questions included were adapted to the level of the participating subjects and whether their formulation was appropriate for the research. Following the guidelines of Ding and Hershberger [88], a test of concordance was carried out among experts, who were given the assessment criteria on which they should mark their degree of agreement or disagreement in a range of 0 to 1. The value obtained for the degree of concordance was 0.90, which can be classified as very good according to the literature.

In addition, several psychometric tests were carried out in order to highlight the reliability of the instrument within the study, as recommended by Ding et al. and McColgan [89,90]. Specifically, the difficulty index, discrimination index, Ferguson's delta, and Cronbach's alpha were calculated using the formulas specified in the previous studies. Table 6 shows the values obtained and the values of the calculated indices recommended in the Ding and Beichner [87]. It can be seen from Table 6 that all the values were within the recommended range in the literature, so the instrument was reliable, with an adequate level of difficulty and discrimination power.

Table 6. Statistical analysis of the measuring instrument.

Coefficient	Obtained Value	Recommended Values
Mean Difficulty Index (*P*)	0.46	[0.30–0.90]
Mean Discrimination Index 1 (D1)	0.54	≥0.30
Mean Discrimination Index 2 (D2)	0.77	≥0.50
Ferguson's Delta (δ)	0.96	≥0.90
Cronbach's Alpha (α)	0.78	≥0.60

The difficulty index indicated the degree of difficulty, so the higher the index the easier the question asked. The value of 0.46 obtained represented the degree of conceptual difficulty of the instrument suitable for the research.

The discrimination indexes expressed the extent to which the instrument differentiates those who know more from those who know less. The Discrimination Index 1 (D1) measured the discriminatory power of each item in a test. Its objective was to check whether there were questions that were too easy or too difficult, that they did not discriminate and therefore did not contribute to the reliability of the instrument. The value obtained (0.54) indicated an adequate discrimination index. Furthermore, the Discrimination Index 2 (D2) indicated the extent to which a question helps to distinguish between those who know more and those who know less, regardless of how easy the question was. Its value is satisfactory if it is at least higher than 0.50, so the value obtained of 0.77 was suitable for the research.

Another source of evidence was the extraction of Ferguson's delta (δ). The literature recommends following the criterion that a test that offers good discrimination power has a δ greater than 0.90. The test in the study had an index of $\delta = 0.96$, so in general terms it offered good discrimination power.

Finally, Cronbach's alpha coefficient (α) was calculated, which is a measure of the reliability of internal consistency. A value of 0.78 was obtained, indicating high reliability.

2.5. Intervention Design

The experience developed was carried out in different sessions. In the first session, common to all the participating sample, a detailed explanation of the contents and an introduction to the activity to be carried out in the following session were given. Likewise, the instrument was implemented as a pre-test with the blocks that referred to the cognitive dimension, environmental attitude, environmental behavior, and emotional dimension (this last block, block 4, was implemented before and after this introductory session).

In the second session, the ICT activities chosen to reinforce the contents explained above were implemented. A WebQuest was implemented with group A, and with groups B and C a video game was selected in each case. Likewise, the emotions questionnaire (block 4) was given before and after the ICT session in both groups.

In session 3 the questionnaire was again implemented as a post-test to evaluate the cognitive dimension (block 1), the environmental behavior (block 2), and the environmental attitude (block 3) of the students after the didactic intervention.

3. Results

This section presents the results obtained in the research. For the processing of the data, and its subsequent interpretation, IBM SPSS 20.0 statistical software was used, elaborating descriptive analyses and non-parametric tests according to the characteristics of the sample. In addition, we worked with a 95% confidence level.

3.1. Cognitive Variable: Pre-Test (Block 1)

The students were given a knowledge questionnaire before and after the didactic intervention. The purpose of these questionnaires was to measure the initial state and subsequent progress of the students in the contents that was worked on in the sequence of activities.

Table 7 shows the descriptive statistics calculated from the number of correct answers by the students in the pre-test. It can be seen in the table that groups A and B have a very similar average, while group C reported worse results in this initial questionnaire. The initial results of group C compared to the rest of the groups were to be expected. As commented in the section describing the sample, according to their teacher the academic performance of group C was notably lower than that of the rest of the groups. Likewise, the values of standard deviation and standard error were very similar between the groups. Table 7 shows the mean over 20 points.

Table 7. Descriptive statistics of the cognitive variable (pre-test).

Group	Mean	Std. Deviation	Std. Error Mean
A	7.15	2.34	0.52
B	7.10	2.40	0.53
C	4.52	2.61	0.54

It can be seen from Table 7 that the students belonging to group A obtained an average score of 7.15 points, with a standard deviation of 2.34 points and a standard error of the mean of 0.52 points. Group B students achieved a score of 7.10 points, with a standard deviation of 2.40 points and a standard error of the mean of 0.53 points. Group C students scored 4.52 points, with a standard deviation of 2.61 points and a standard error of the mean of 0.54 points. These pre-test results were in line with expectations because many of the questions may have been unfamiliar to them.

After the descriptive statistics obtained in the pre-test for each set, we checked whether the starting point of the cognitive level was common in all study groups. To do this, the first step was to apply the Kolmogorov–Smirnov test to the correct answers that each student had made in the three groups. The results of the test revealed that of the three groups, only group A has a normal distribution (Sig > 0.05). Therefore, the non-parametric Mann–Whitney U test was used to compare the groups. As these involved comparisons between the three groups, the Kruskal–Wallis H statistical test for independent samples will be presented first.

Table 8 shows the statistics average ranks obtained by each student group and Table 9 shows the inferential analysis performed with the Kruskal–Wallis statistical test to compare the groups.

Table 8. Average ranks obtained by group.

	Group	Mean Rank
Correct answers	A	38.53
	B	38.98
	C	20.26

Table 9. Kruskal–Wallis test for independent samples. Comparison between groups.

Test Statistics	
	Correct answers
Kruskal–Wallis H	15.164
Asymp. Sig.	0.001

The data presented in Table 9 shows that the average results obtained in group A and B differed quite a bit from group C. Table 9 also reveals the existence of statistically significant differences between the study groups, having obtained a significance = 0.001 in the Kruskal–Wallis group comparison test. Table 10 shows the data obtained after the paired comparison using the Mann–Whitney U-test.

Table 10. Mann–Whitney test comparing groups two groups (pre-test).

	GA vs. GB	GA vs. GC	GB vs. GC
Mann–Whitney U	190.000	89.500	100.500
Wilcoxon W	400.000	365.500	376.500
Z	−0.274	−3.464	−3.184
Asymp. Sig. (2-tailed)	0.784	0.001	0.001

According to the results in Table 10, obtained after inferential analysis with the non-parametric Mann–Whitney U test to compare groups two by two, groups A and B started from a similar level

(Sig. = 0.784), while group C obtained worse results than the rest, the difference being equally significant (Sig. = 0.001) in both comparisons.

According to the analysis carried out, group C obtained worse results than the other groups and with a significant difference between the results obtained by this group and the others; that is, it obtained worse results in the previous questionnaire than the rest of the groups initially. This statement coincides with the observations made by the teacher of the three groups, who already indicated that this group obtained in general worse grades than the others. This difference would indicate that the three groups did not have equal levels at the beginning of the proposed sequence of activities, which would have to be considered in the subsequent results.

3.2. Cognitive Variable: Pre-Test vs. Post-Test (Block 1)

This section shows the results obtained by the participating sample in the post-test and a comparison of the pre-test results with the post-test results.

Table 11 compares the results obtained in the pre-test and the post-test for each of the three groups. Table 11 shows the increase in the score obtained by each study group in the post-test when compared to the pre-test. The value of the effect size, calculated as the difference between the post-test knowledge mean level minus the pre-test knowledge mean level and divided by the pre-test standard deviation, is also presented. The results in Table 11 confirm that there was an improvement in all three groups after the second session, which indicates that the intervention produced an improvement in the students' level of knowledge.

Table 11. Improvement in the mean score of the three groups.

Group	Pre-Test Mean	Pre-Test SD	Post-Test Mean	Post-Test SD	Learning Gain	% Improvement	Effect Size
A	7.15	2.34	9.40	4.87	2.25	31%	0.96
B	7.10	2.40	10.45	3.86	3.35	47%	1.39
C	4.52	2.61	7.96	3.77	3.44	76%	1.31

The data shown in Table 11 indicates that group A improved its score from the pre-test by 31% over the initial knowledge by obtaining 9.40 correct answers on average in the post-test. Group B improved its score by 47% with respect to the initial knowledge by obtaining 10.45 correct answers on average. Group C improved by 76% with respect to initial knowledge after going from 4.52 correct answers in the pre-test to 7.96 in the post-test. The improvements achieved by the groups that used the video games were superior to the improvement obtained by group A, which used the WebQuest. These results can be verified with the effect size values shown in Table 11. The groups that used the video games (Groups B and C) had a similar and higher effect size than the group that used the WebQuest (Group A). In view of these results, it was considered necessary to analyze the progress experienced by each of the groups to verify whether there had been a significant improvement in all cases.

Firstly, the Kolmogorov–Smirnov test was carried out and the results indicated that the data for groups B and C were not normally distributed. Therefore, the Wilcoxon–Kruskal–Wallis non-parametric test was used to compare the pre-test and post-test results of all groups. The results of this test are shown in Table 12.

Table 12. Wilcoxon–Kruskal-Wallis test for groups A, B, and C comparing the cognitive variable (pre-test vs. post-test).

	Group A	Group B	Group C
Z	−1.901	−3.117	−3.241
Sig. (2-tailed)	0.057	0.002 *	0.001 *

* Sig. < 0.05.

As shown in Table 12, the post-test results indicate that all three groups made progress, suggesting that all interventions have produced a small improvement in students. A Sig. = 0.57 was obtained in group A; that is, in group A, where the WebQuest was implemented, no statistically significant improvement was found. On the other hand, according to the results of the test, only groups B and C experienced a statistically significant progress with respect to their initial level of knowledge. Group B had a Sig. = 0.002 and group C had a Sig. = 0.001, so it could be assumed that both groups did experience significant improvement after the intervention. In any case, this was a question of measuring the progress of the students more than the score obtained. Thus, group C, although it obtained worse results than the rest of the groups in both questionnaires, was the one that experienced greater progress, going from 4.52 to almost 8 on average. These results show that the three ICT-based educational interventions that were carried out were effective in improving the level of knowledge of the students in the sustainability issues under study.

However, although all three groups improved, only groups B and C, which used video games, showed a statistically significant improvement. Along these lines, we agree with the authors of [51] when considering that video games can be beneficial for learning science content. As some authors point out [48,49], video games have great potential from an educational point of view.

These results allow us to accept Hypothesis H1 posed in this research, "The use of ICT-based active methodologies improves the level of knowledge of secondary school students in relation to sustainability concepts".

On the other hand, an inferential statistical analysis was carried out to compare the post-test scores obtained by each group in order to analyze whether there were differences between the use of video games and the use of WebQuest.

Table 13 shows the results obtained in the Mann–Whitney U test comparing the post-test scores of two groups.

Table 13. Mann–Whitney test comparing two groups (post-test).

	GA vs. GC	GA vs. GB	GB vs. GC
Mann–Whitney U	191.500	162.500	143.000
Wilcoxon W	467.500	372.500	419.000
Z	−0.942	−0.775	−2.129
Asymp. Sig. (2-tailed)	0.346	0.438	0.033 *

* Sig. < 0.05.

If we look at Table 13, we obtain values of significance greater than the reference value 0.05 in the comparisons between group A vs. group C (Sig. = 0.346) and between group A vs. group B (Sig. = 0.438). In other words, there were no significant differences between the group that used WebQuest and those that used video games. These data obtained lead us to reject Hypothesis H2, "There are no statistically significant differences in the use of video games versus the use of WebQuest for learning concepts related to sustainability". However, there were differences between the two video games used (Sig. = 0.033). This may be because group B's video game *My Green Energy Planet* focused the students' attention more on the concepts under study than group C's video game *Control of the Spanish Network*.

3.3. Analysis of the Cognitive Results of the Post-Test by Content Blocks (Block 1)

This section presents the cognitive results of the post-test, distinguishing between the established content blocks: Sustainability, Renewable energies and Saving measures. Table 14 shows the differences for the different groups.

Table 14. Average progress of post-test versus pre-test students for each block of the questionnaire.

Block	Group	Post-Test vs. Pre-Test
Sustainability	All	1.65
	A	1.30
	B	1.50
	C	2.08
Renewable energies	All	0.82
	A	0.60
	B	1.05
	C	0.82
Saving measures	All	0.55
	A	0.35
	B	0.80
	C	0.52

The values shown in Table 14 provide some insight into the progress experienced by the students for each content block and group after the intervention. According to the results obtained by all the groups as a whole in the post-test, the block with the greatest progress was that of sustainability. This was followed by the blocks on renewables and saving measures, respectively. If we analyze the data by group, we can see that all the groups achieved an improvement from pre-test to post-test in terms of the level of knowledge about the sustainability block. Likewise, an improvement was also observed, although to a lesser extent than in the previous case, in relation to the block on renewable energies. In this case, it was group B that obtained a better score compared to groups A and C. Finally, concerning the block of savings measures, it can once again be seen that it was group B that improved its level of knowledge the most, and it was in group A that progress was less marked. In the inferential analysis carried out to analyze whether there were statistical differences in the progress obtained in each block depending on the group, the following results were obtained.

For group A, the significance value between the comparison of blocks 1 and 2 was Sig. = 0.110, i.e., there was no significant difference in the post-test between the progress obtained in block 1 and block 2. For blocks 2 and 3, a Sig. value = 0.691 was obtained, so there was no significant difference in the post-test between the progress obtained in block 2 and block 3.

With respect to group B, a value of Sig. = 0.531 was obtained in the comparison between block 1 and 2 and a value of Sig. = 0.305 in the comparison between blocks 2 and 3.

Finally, in group C, a value of Sig. = 0.019 was obtained in the comparison in blocks 1 and 2 and a value of Sig. = 0.494 in the comparison in blocks 2 and 3. These results indicated again that no statistically significant differences were obtained in the average progress between blocks 2 and 3, although there was a difference between blocks 1 and 2 in group C. Based on these results, we can indicate that, although the progress experienced by students differed from one block to another, these differences in progress were not found to be significantly different.

3.4. Environmental Behavior Variable (Block 2)

This section presents the results obtained with reference to block 2 of the questionnaire on environmental behavior. To evaluate this section, a summation of the items chosen in each statement was made; that is, the scores obtained by the students in the pre-test and post-test were calculated, the minimum being 9 points (indicative of bad environmental behavior) and the maximum being 45 points.

Table 15 shows the mean scores and standard deviation for each of the groups.

Table 15. Mean of the scores obtained by each of the groups in the pre-test and the post-test in the environmental behavior block.

	Group A			Group B			Group C		
	Mean	**Std. Deviation**	**Sig.**	**Mean**	**Std. Deviation**	**Sig.**	**Mean**	**Std. Deviation**	**Sig.**
Pre-test	31.71	5.93	0.319	32.05	8.03	0.463	31.96	5.98	0.463
Post-test	33.47	4.00		33.20	8.12		32.83	4.80	

With the data shown in Table 15, it can be verified that no significant changes took place in the environmental behavior of the students after the intervention, regardless of the methodology used. Furthermore, this is confirmed by the inferential analysis carried out by obtaining significances greater than 0.05 in all the cases analyzed. Specifically, in the inferential statistical analysis used to calculate whether there were statistically significant differences between the pre-test and post-test in the environmental behavior variable, the following values of significance were obtained: for group A, a Sig. = 0.319; for group B, a Sig. = 0.463; and for group C, a Sig. = 0.204.

The above results lead us to reject Hypothesis H3, "The use of ICT-based active methodologies promotes environmental behavior in students".

3.5. Environmental Attitude Variable (Block 3)

This section presents the results obtained in block 3 of the questionnaire aimed at checking whether the intervention produced changes the environmental attitude of the students. To do this, a score per student was calculated by recoding inversely the questions that scored negatively. Bearing in mind that there were nine questions with five levels, the score obtained by each student could range from 9 to 45. The results are shown in Table 16.

Table 16. Mean of the scores obtained by each of the groups in pre-test and post-test in the environmental attitude block.

	Group A			Group B			Group C		
	Mean	**Std. Deviation**	**Sig.**	**Mean**	**Std. Deviation**	**Sig.**	**Mean**	**Std. Deviation**	**Sig.**
Pre-test	30.94	5.64	0.563	28.65	3.91	0.232	31.04	3.59	0.996
Post-test	31.94	5.12		30.25	4.31		31.00	5.17	

As can be seen in Table 16, the changes in scores were minimal. Inferential statistical analysis revealed no statistically significant differences for any of the three groups (Sig. > 0.05). Specifically, group A obtained a Sig. = 0.563; group B, a Sig. = 0.232; and group C, a Sig. = 0.996. Accordingly, it was ruled out that the intervention has produced any change in the environmental attitude of the students, thus rejecting Hypothesis H4, "The use of ICT-based active methodologies promotes an increase in the level of sustainable attitudes among secondary school students".

3.6. Emotional Variable (Block 5)

Finally, the results obtained in the emotional variable are presented. It should be noted that this section of the test (block 5) was carried out on four occasions: before and after the introductory session, and before and after the reinforcement session by means of WebQuest for group A and video games for groups B and C.

Table 17 shows the percentages of students who selected each of the emotions before the introductory session and the percentages of students who selected each of the emotions after the reinforcement session.

Table 17. Percentage of students who felt each emotion before pre-test vs. after post-test.

		Group A		Group B		Group C	
		Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
Positives	Joy	42.90	39.39	29.60	44.40	23.10	46.20
	Satisfaction	28.60	42.90	18.50	40.70	15.40	19.20
	Surprise	39.30	21.40	48.10	33.30	11.50	11.50
	Fun	25.00	25.00	25.90	44.40	19.20	46.20
	Confidence	39.30	25.00	29.60	40.70	38.50	34.60
	Average	35.02	30.74	30.34	40.70	21.54	31.54
Negatives	Boredom	46.40	32.10	59.30	29.60	38.50	23.10
	Nervousness	14.30	3.60	44.40	18.50	7.70	46.20
	Fear	3.60	3.60	18.50	0.00	3.80	7.70
	Concern	3.60	3.60	23.10	25.90	22.20	7.70
	Anxiety	10.70	10.70	25.90	14.80	19.20	38.50
	Average	15.72	10.72	34.24	17.76	18.28	24.64

The data shown in Table 17 indicates that there was no clear trend among the groups regarding the manifestation of emotions before the introductory session. If we observe the overall results of negative emotions and positive emotions before carrying out any intervention, we can say that students from groups A and C showed mostly positive emotions, and, on the contrary, students from group B showed mostly negative emotions. The positive emotion that stands out the most was surprise in groups A and B, which is logical because the students did not know what activity was going to be carried out with them. On the contrary, the positive emotion most expressed by group C was confidence, although it is true that high results were also observed in this emotion in the rest of the groups before carrying out the introductory session. Likewise, it is striking that the most felt emotion in all the groups before the introductory session was boredom, felt by between 40% and 50% of the sample. These results are similar to previous studies that suggest that most students experience boredom during lectures [86].

With regard to the analysis of emotions after the reinforcement session (WebQuest with group A and video games with groups B and C), it should be noted that there was an increase in the manifestation of positive emotions compared to the pre-test in groups B and C and a decrease in them in group A. However, the average values of positive emotions exceeded the negative ones in all groups of students in the post-test. If we make an exhaustive analysis by emotion, it should be noted that the boredom emotion decreased in all cases, and the fun emotion maintained its value in group A as opposed to the introductory pre-test and increases in groups B and C. This suggests that the implementation of ICT activities in the classroom favored the internalization of the contents learned in the introductory session, since the students demonstrated a greater emotional well-being. However, it was the video games that favored this well-being to a greater extent, so that it does seem that the game had positive effects on the emotions in these groups when compared to those who used the WebQuest, although they do not seem to be very significant. On the other hand, the joy emotion only increased in groups B and C (video games) and decreases in group A (WebQuest).

Although the changes were not significant, there was a slight advantage in favor of the use of video games, especially in terms of positive emotions, which improved with the video game to a greater extent than with the WebQuest activity. This difference was quite clear in the emotions of boredom and fun, which varied greatly thanks to the use of the video game in the classroom. Although this suggests that Hypothesis 5, "Secondary school students show different emotions depending on the ICT methodology used in the classroom", is correct, more research is needed on this issue.

3.7. Assessment and Self-Evaluation (Block 4)

Once the intervention was finished, block 4 was included in the questionnaire for the students' evaluation of the activities carried out, as well as of their own learning. Only some items were included referring to each of the activities. This block also intended to obtain some additional information

about the proposed reinforcement activity, the WebQuest or the video game, depending on the group, and the opinion that the students had formed about what they had learned and the proposed way of working. This block of the questionnaire is considered very important because it could give some clues about possible lines to improve the design of the sequence of activities presented to the students. The following is an analysis of the students' answers.

About the students' assessment of the introductory session as an exposition, it should be noted, except for group C, that around 40% of the students in groups A and B liked the introductory session. Specifically, 37% of the students from group A and 42% from group B chose the item "Totally agree" for this assessment. In the case of group C, 52% of students select the item "Disagree". These differences show that a methodology does not have to be good in all contexts, nor does it have to be liked or benefit all types of students to the same degree.

With respect to the evaluation of the reinforcement activity, it was obtained again that around 40% of the students in study groups A and B liked the activity that was proposed to them. It is assumed that students in groups A and B showed a similar interest in the reinforcement teaching methodologies, the WebQuest and the *My Green Energy Planet* video game. However, in group C, only 32% of the students showed a preference for active learning with video games.

The results on the assessment of the didactic validity of the reinforcement activity indicate that the activity implemented with the students of group C, the video game *Control of Spanish Network* was the worst evaluated, since only 24% of the students chose the option "Totally agree" regarding the didactic assessment of this video game. However, we must consider that the game presented some problems when used in the classroom, and these reasons could have produced this result, which is still considered good considering the problems experienced. With respect to the evaluations made by group A, it is worth noting that more than 40% of the sample chose the item "Totally agree"; that is, this group positively valued the WebQuest as a didactic tool. Finally, it is worth noting that almost 50% of the students in group B also selected this item, which suggests that the video game *My Green Energy* Planet was the best evaluated in reference to its educational potential in the classroom.

Regarding the duration of the reinforcement activity, in group A 35% of the students thought that the activity was adapted to the established times and less than 10% thought that it was too short. Thus, it is assumed that those who used the WebQuest did not need more time to work. On the other hand, over 40% of group B students and 37% of group C students felt that more time should have been spent on the reinforcement activity, i.e., that the time available for the video games was too short.

When assessing the relationship between the activity and the topic, very similar results were obtained between the groups. Among 13% of students who used the WebQuest considered that the activity was not related to the topic of study and about 20% of the students in groups B and C thought the same. On the other hand, more than 50% of the students in groups A and B and 48% of the students in group C thought the opposite, that the reinforcement activity was focused on complementing the introductory theory session.

It was also sought to assess whether the students thought that they had learned something about sustainability after the experience. The results confirmed that the students in group B who used *My Green Energy Planet* were the ones who best valued the learning acquired, followed by group A with the WebQuest, and finally group C. The results obtained with group C coincided to some extent with those found by the authors of [91], who concluded in their study that students who used a video game to supplement learning obtained better grades but rated their performance worse than those who did not use it.

The above results allow us to accept Hypothesis H6, "The participating students value positively the intervention carried out in the classroom, regardless of the ICT activity implemented".

3.8. Gender Differences

Finally, it was decided to check whether gender influences positive opinions of computers and video games.

With regard to positive opinions of computers, some authors have found that many more men than women obtain computer science degrees [70], and, moreover, the PISA 2015 report [92] indicates that boys aspire to be computer scientists more often than girls. In this sense, the results of this study revealed that male students liked computers more than female students. Specifically, 39.3% of male students chose the options "Totally agree" and "Agree", respectively when responding to the statement "I like computers", compared to 19% of female students who marked these options. We thus agree with this research which shows that boys show a greater preference than girls for these areas [70,92].

With respect to the statement "I love video games", it was also verified that the gender had some influence, as 67.9% of the boys show great preference towards them as opposed to 14.3% of the girls, thus contrasting previous studies by the authors of [75].

These results confirm Hypothesis H7, "There are differences in the preferences for computers and video games according to the gender of the participating students".

4. Discussion and Conclusions

The results allow us to conclude that ICT activities with educational purposes promote good learning in students, especially those who use video games as their main activity. Specifically, students who used an educational video game obtained higher results than those who learned the contents from an alternative ICT methodology [93]. On the other hand, it is concluded that the educational proposal did not represent an improvement in the behavior and environmental attitudes of the students, since the data obtained inform us that, generally, students already act responsibly regardless of the type of education received. However, it should be noted that it is very difficult to change environmental attitudes and behaviors in people by carrying out only one classroom session, since, according to some studies, attitudes and beliefs are usually deeply rooted and difficult to modify in the short term [18]. In this sense, the ideal way to change student behavior would be to expand the classroom intervention using active methodologies, because these foster positive emotions and feelings and will facilitate change in expectations and beliefs about the subject of study [94].

Continuing with the emotional sphere, it is worth highlighting the results obtained in the emotion of boredom, which demonstrated the greatest changes throughout the activities. Specifically, it is concluded that the exposition sessions and the traditional activities increased the appearance of this emotion in the students and the video games had a positive effect on this emotion by reducing its manifestation in the students who worked with them. In this line, we agree with the authors of [95] that the integration of active methodologies in the classroom contributes to favoring scientific literacy and creative capacity in students by placing them in front of diverse tasks that lead them to seek different ways and means of solution.

In addition, video games are not far removed from exclusion based on gender in two ways: in their use and in their reflection of gender stereotypes [96]. This study assumes that variables such as gender still seem to affect student preferences, as it was found that computer or video games are mostly liked by the boys, as opposed to the girls, who participated in this study [75]. This leads us to think that context could be a determining factor when choosing the appropriate teaching strategy for the entire group of students. Therefore, these results carry a clear commitment to the transformation of the education, practice, and management of science and technology. ICT needs to be addressed more frequently in the classroom in order to prevent girls from becoming more reluctant than boys, and thus further reinforcing gender stereotypes on these issues.

Finally, we conclude that ICT activities, and specifically video games, can not only help develop skills and abilities but can also contribute within the learning process to the acquisition of specific knowledge or education in values [97]. However, the use of video games for educational purposes is a complex issue that may require a significant effort from teachers. In the first place, there are no video games for all the content in the curriculum, and, therefore, on many occasions it would be necessary to adapt the content offered by existing video games. This means that proposals for this type of teaching material are very limited unless one is developed for the occasion, which would often

make the teaching task a challenge. Furthermore, it is only on rare occasions that video games are accompanied by the corresponding teacher's guidance or information to guide their integration in the classroom, which would make the teacher's work even more complex. Likewise, the access to and use of technologies in the classroom presents a clear hierarchy between teachers and students, since they are implemented in such a way that they respond more to the needs of teachers than to those of students, who find their access limited and conceptualize them as a tool for controlling study rather than as a learning tool [98]. In this sense, we agree with the authors of [44] on the need to use ICT environments in a more interactive and stimulating way because they would make higher quality learning possible. However, this requires the implementation of training plans for teachers at all levels of education so that technological literacy can be developed effectively. Without specific teacher training, the task of bridging the digital divide and therefore of providing technological literacy to students would be impossible [99].

The new generations have modified their ways of learning, playing, and communicating. Knowledge management is mediated by technology and new connections are generated all the time and everywhere, so video games can become a learning opportunity for the student [76]. However, there is still much to explore, as some research [100,101] highlights that there is some resistance among teachers to considering video games as tools for learning because they are part of leisure time, and there are also some students who have problems establishing a connection between playing and learning [102]. In this sense, it is especially relevant to carry out studies that show the potential of video games in promoting creativity in the classroom [99] and the need to integrate audiovisual literacy in the initial training of teachers, giving special importance to the use, creation, and didactic management of video games [103]. In this line, our research proposal aims to make the educational purposes of video games visible so that they are recognized by the teaching community in order to guarantee satisfactory teaching results and the necessary motivation to learn science, taking advantage of the ease with which new generations of students master ICT [103].

As a future line of research, we plan to integrate audiovisual literacy into the initial training of teachers not only to improve their professional development, but also to show them the importance of the use, creation, management, and evaluation of the didactic use of video games. The challenge is there; it is up to us to take advantage of it and to explore it with an open mind.

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