

Letter

Effectiveness of Innovate Educational Practices with Flipped Learning and Remote Sensing in Earth and Environmental Sciences—An Exploratory Case Study

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Received: 24 January 2020; Accepted: 8 March 2020; Published: 10 March 2020



Abstract: The rapid advancements in the technological field, especially in the field of education, have led to the incorporation of remote sensing in learning spaces. This innovation requires active and effective teaching methods, among which is flipped learning. The objective of this research was to analyze the effectiveness of flipped learning on the traditional-expository methodology in the second year of high school. The research is part of a quantitative methodology based on a quasi-experimental design of descriptive and correlational type. Data collection was carried out through an ad hoc questionnaire applied in a sample of 59 students. The Student's *t*-test was applied for independent samples, differentiating the means given between the experimental group and the control group. The results show that there was a better assessment of the teaching method through flipped learning than the traditional teaching method in all the variables analyzed, except in the academic results, where the difference was minimal. It is concluded that flipped learning provides improvements in instructional processes in high school students who have used remote sensing in training practices. Therefore, the combination of flipped learning and remote sensing is considered effective for the work of contents related to environmental sciences in said educational level.

Keywords: ICT; flipped learning; Remote Sensing; UAV; educative technology; environmental sciences; experimentation

1. Introduction

The advancement of society in technological matters is already a reality embodied in different areas of life, among which social, labor, and education stand out. Technology has contributed to the performance of daily tasks with less effort and more efficiency [1].

In particular, in the field of education a whole revolution is being experienced, where information and communication technologies (ICT) have settled and expanded to carry out the different educational tasks [2]. The innovative training action has unleashed new spaces that enrich learning. Among the potential of the inclusion of ICT in education is the active profile assumed by the student, being the main manager of their knowledge, and the emergence and continuous development of new ways and resources to teach and learn the didactic contents [3,4].

This progress in the educational world has led to a fusion between technologies and training methodologies, leading to a whole transformation in the classrooms [5]. All this has caused the physical barriers of learning to be broken, and it can be carried out at any place and at any time, thanks to the ubiquity conferred by today's technopedagogy [6].

The new innovative actions incorporated into the educational system have produced a substantial improvement in different indicators of students, such as motivation, autonomy, participation, and attitude, among the most prominent by recent educational research [7–9].

The new technoeducational media have allowed the development of a different teaching and adapted to the new times where technology assumes an important value [10]. This has allowed the generation of digital learning spaces through platforms that contain all the information and audiovisual content to enjoy an instructional action using a device with Internet access [11].

These mentioned advances have caused education to be renewed and adapted to the singularities of an era conditioned by the large amount of information that surrounds us and is easily accessible [12,13]. All these innovations have resulted in the improvement of the training quality both in the teacher's training work and in the role of the apprentices of the new millennium [14]. Therefore, the projection of educational technology has encouraged the emergence of new ways to achieve the transmission of knowledge. Within the wide catalog of active methodologies that emerged with the progress of ICT is flipped learning (FL), conceived as one of the formative approaches that is rapidly acquiring growth [15].

Based on the characteristics of the current socio-educational paradigm, this research focuses on analyzing how the early implementation of remote sensing data (acquisition of small- or large-scale information of an object) provided by unmanned aerial vehicles (UAV) can support learning, specifically in the flipped learning methodology. This innovative approach can address any competence within the educational field, contributing especially to students understanding the environmental complexity of the landscape and the natural phenomena of creation and destruction of the land.

1.1. Characteristics of the FL Approach

The FL is presented in the impact literature as an innovative teaching and learning methodology that combines the traditional presence of training actions with the virtuality generated by educational content management platforms. All this makes it an instructive approach of mixed nature [16]. This novel and popular way of imparting and learning the contents is already being applied in the different educational levels, highlighting both its good acceptance by the different educational agents and the relevant results obtained from its implementation [17–19].

Originally, the FL was created with the objective of increasing the practice time of the students in the face-to-face sessions, and to favor the interactions produced between them and the teacher, the contents, and among themselves, always starting from the previous needs and knowledge of the students [20,21]. In addition, the temporary gain allows us to deepen the contents and develop problem-solving autonomously [22].

To achieve this greater time interval in the physical classroom, it is necessary for the teacher to generate audiovisual materials of the contents to be taught, and manage them in an educational content management platform so that students can have access to them [15]. In this way, students can see the teaching materials prior to the face-to-face session [23–25].

The FL has caused a change reflected in an investment of moments. First, the students have to visualize the digital contents outside the classrooms, in any suitable space where the learning material (tutorials, webinars, papers, videos of lectures, etc.) can be used with tranquility and concentration. Second, in the physical classroom, externally viewed content is analyzed in greater detail and all students' doubts are resolved. This turnaround produces an increase in class time that can be used by the teacher to deepen the content and generate more dynamics that reinforce what has been learned [26,27]. Likewise, individualized learning is encouraged, as students can visualize the time that digital content requires, at any time, place, getting an adaptation to the needs of each person [28].

The change produced by the FL in the learning spaces has resulted in new roles for the teacher, who now acts as a guide for all instructional action, and the student, who develops an active profile and promoter of their own learning [29]. This has led to significant improvements in various items connected with students, such as motivation [30], teamwork [31,32], commitment to homework [33],

the interactions produced between teachers and speakers, as well as with the didactic contents [34,35], the active participation and protagonist of the students [36], autonomy as manager and builder of his wisdom [37], and in the positive attitude of students [38], as academic indicators highlighted in the scientific literature. These improvements mentioned positively and directly the condition performance shown by students in their day-to-day [39]. Consequently, all this results in the improvement of the qualifications in the evaluation tests [40,41] and in the scope of the objectives by the students [42–44].

The literary findings reported in sources of impact demonstrate that the FL, in comparison with traditional formative methodologies of an expository nature without the use of digital resources, becomes an effective teaching and learning approach in different subjects and educational levels [15,29,45–49].

1.2. Use of Remote Sensing in Learning Spaces

The rapid development of modern 3S technology (remote sensing, Geographic Information Systems, and Global Positioning Systems) and the rise in digital landscape research worldwide [50] have led to the development of new forms of teaching with the use of remote sensing [51,52], in various educational stages, especially in higher education [53] and in its previous stage [54].

The most prominent trend in the inclusion of remote sensing in learning spaces is the implementation of Augmented Reality (AR). Recent research proposes the inclusion of remote sensing to stimulate the motivation of students in the use of new media within the STEM (Science, Technology, Engineering, and Mathematics) curriculum [55]. In these digital learning modules, augmented reality tools are used to communicate the knowledge of natural phenomena caused by human beings in the era of globalization [56]. Through the visualization of three-dimensional animations with AR, theoretical subjects [57] related mainly to two sections can be visualized: the physics of remote sensing (with special importance on mathematics and computer science) and geographical applications [58].

The constant advancement of geospatial technologies and their integration in UAV (Figure 1) makes it a suitable methodological resource to be used in university content and careers related to geography [59,60]. UAV allow you to capture images of various landscapes (Figure 2). This speeds up and facilitates the approach of students to the natural environment of their context.



Figure 1. UAV (unmanned aerial vehicle) used for remote sensing.

The use of UAV based on remote sensing technology within the student learning process is still in an expansion process [59]. Although it is an emerging resource, it is currently used more and more frequently in issues related to the following educational topics:

- Development of maps and realization of tours at a geographical level;
- Calculation of distances, geometry, and temporal graphs in mathematics;
- Development of multidisciplinary projects that include photographs, murals, and maps;

- UAV manufacturing for students of specific subjects, such as trigonometry, robotics, programming, or electronics;
- Recording of events for inclusion in digital and written media (school blog, university newspaper, educational television);
- Development of fine motor skills and hand-eye coordination through specific UAV driving along an obstacle course;
- Recording of physical education sessions for the optimization of student exercises, strategies, and movements.



Figure 2. Aerial view of landforms and the coast: (a) UAVs allow students to know the complexity of the terrestrial landscape, the characteristics of elevations and depressions in the lithosphere. They also allow in-depth observation of the great forms of the relief: ancient massifs, sedimentary basins, or sedimentary plains and mountain ranges of recent formation. (b) UAVs used for remote sensing allow students live knowledge about the two main phenomena of marine erosion: sea currents and waves. Also, this tool makes it possible to know the effects of maritime erosion: cliffs, abrasion platforms, coastlines, sea caves, and peninsulas.

All this has been reflected in the educational field, where it has been shown that innovative teaching methods such as e-learning [61], project-based learning [62], mobile learning [63], and research-based learning [64] are effective training methodologies in combination with remote sensing. On the contrary, the use of traditional teaching methods such as the exposition method [65] does not imply major improvements in the academic indicators of the students, as do the previously mentioned methodologies [66].

Next, the following sections aim to establish a theoretical and conceptual framework based on the characteristics of the flipped learning methodology and the use of remote sensing in the teaching and learning processes. Likewise, the objectives of the investigation based on their respective justification (study problem) are presented. Furthermore, the materials and methods used in the research design, the data analysis, the characteristics of the sample participants, the instruments used for data collection, and the procedure of the research process will be specified. On the other hand, the results obtained during the investigation process will be presented, which will be discussed with results found in other similar investigations. Finally, the final conclusions of the study will be presented, in addition to exposing the main limitations found and proposing future lines of research.

1.3. Justification and Objectives

The influence of technology in today's society implies the alteration of the teaching and learning processes towards more techno-pedagogical approaches where ICTs have a great role in the different actions carried out in the learning spaces [5,67]. This statement is demonstrated in the innovative teaching experiences that are nowadays put into practice in the classroom. Specifically, in this

investigation a robotic element of remote sensing (UAV) is used during the teaching and learning process. This technological resource is supported from two different methodological perspectives (traditional and FL) according to the group of students.

As presented above, the scientific literature does not reveal any study concerning the combination of remote sensing devices with the FL methodology. Therefore, this research acquires an exploratory nuance to establish new knowledge bases on the state of the matter. In addition, with the completion of this work a starting point will be created for future researchers to establish replicas and comparisons with other levels and educational contexts.

In our case, this is carried out in the subject of Earth and environmental sciences, due to the use of the UAV in natural areas of the geography where the study is carried out. The purpose of using this robotic resource is to quickly bring students closer to those areas that are difficult to access during school hours and the security they transfer, since students do not suffer any danger when walking through rocky and mountainous places. Also, the UAV effectively allows the taking of images of the different places through which it moves. This allows teachers to make more enlightened explanations and bring students closer to the existing reality of their context. On the other hand, the use of FL makes it possible to renew and bring the lessons closer to the intrinsic characteristics of the contemporary era where technology plays an important role [68].

The purpose of this study is to continue investigating the effectiveness of the FL approach in the different subjects, levels, and educational contexts, as found in the literature [15,17–19,33,45,47–49,69]. To find out the methodological effectiveness, the experiment is produced in contrast to a traditional methodology, where the teacher simply transmits the contents orally and does not rely on platforms, applications, or digital presentations [70]. The experimentation is carried out in the second year of high school due to the habitual and familiar contact that students present at these ages with technology [71], with the intention of reducing the bias due to lack of digital competence of the participants.

Therefore, the main objective of this study is to analyze the effectiveness of FL on a traditional-expository methodology in the second year of high school. As specific objectives to conduct the research, the following are formulated: (a) to determine the level of motivation of the students; (b) to know the level of interaction (teacher-student, student-student, student-content); (c) to discover the level of autonomy of the students; (d) to find out the level of collaboration of the students; (e) to know the level of deepening of the didactic contents; (f) to decree the level of problem-solving in the proposed activities; (g) to discover the level of class-time; (h) to find out the alteration of the grades according to the training methodology used.

2. Materials and Methods

2.1. Research Design and Data Analysis

To carry out the research, a quantitative methodology based on a quasi-experimental design at the descriptive and correlational level was chosen. During the development of the study, the guidance of experts in the field was followed [72,73], and recent studies that used the same research structure [29,45,47].

In this experimentation two groups of analyses were set up, one control and the other experimental, which followed different training methodologies. The first, the control, was chosen to impart the contents in a traditional way based on the reproduction and exposure of the contents by the teacher without the use of innovative resources. The second, the experimental one, received a formative action through FL. Both groups used the UAV to carry out the practices of the contents, establishing the difference only at the methodological level. This approach established the teaching and learning methodology as an independent variable and the resulting effectiveness in the different academic indicators derived from teaching practice as a research dependent variable.

The Statistical Package for the Social Sciences (SPSS) v25 (IBM Corp., Armonk, NY, USA) program was used to analyze all the data collected. Specifically, the statistics used were the mean (M) and

standard deviation (SD). Likewise, to mark the distribution trend, skewness (S_{kw}) and kurtosis (K_{me}) tests were performed. Next, the Student's t -test (tn_1+n_2-2) was used to display the comparison of the means between the control and experimental groups. Finally, with the application of Cohen's d and biserial correlation (r_{xy}) the effect size was obtained. Throughout the statistical analysis, we worked with a level of significance of $p < 0.05$.

2.2. Participants

The study sample was established in 59 students of the second year of high school of an educational center in southern Spain. These subjects were chosen by an intentional sampling technique, justified in the ease of access to students. In an analysis of the impact literature on this type of research, the number of participants determined neither the development nor the results of the experimentation [74,75].

Sociodemographically, 38.98% were men and the rest were women, who reached an average age of 17 years ($SD = 1.63$). These students articulated two study groups (control and experimental). The treatment applied was established in a probabilistic way in one of the groups and only a single measurement was taken in them (Table 1).

Table 1. Group composition.

Group	n	Composition	Pretest	Treatment	Post-Test
1—Control	30	Natural	-	-	O ₁
2—Experimental	29	Natural	-	X	O ₂

Note. The treatment was assigned randomly.

2.3. Instrument

The tool used for the data collection process was an ad hoc questionnaire, prepared according to other instruments reported in the impact literature on the state of the matter [15,47,76,77]. The questionnaire was structured in nine dimensions: 1—socioeducational, 2—motivation; 3—interactions; 4—autonomy; 5—collaboration; 6—depth of content; 7—problem resolution; 8—class-time; 9—ratings. In total, the instrument had 35 items. The questions were established with a Likert rating scale (from 1 = none to 4 = completely).

The tool was qualitatively validated by the Delphi method, composed of a panel of eight experts who offered an adequate assessment ($M = 4.64$; $SD = 0.37$; $min = 1$; $max = 6$) and observations related to the reduction of the initial number of items and the modification of certain constructs to improve the understanding of the issues. All the feedback received by the specialists was taken into consideration to improve and optimize the questionnaire and, therefore, reduce any bias in the investigation.

Next, the qualitative validation was analyzed by the Kappa de Fleiss and W de Kendall statisticians, with the intention of reaching the degree of agreement and relevance of the observations received. The results of these tests were adequate ($K = 0.84$; $W = 0.86$), allowing to settle the judgments of the experts.

At a quantitative level, the questionnaire was validated by exploratory factor analysis by the principal components method. Dependency was reached between the variables with Bartlett's test of sphericity (2613.28; $p < 0.001$) and a relevant sample adequacy revealed in the Kaiser–Meyer–Olkin test ($KMO = 0.87$).

The reliability of the instrument was developed using the statistics Cronbach's alpha (α) (0.86), compound reliability (0.84), and mean variance extracted (0.81). These results revealed an adequate internal consistency in the designed questionnaire.

2.4. Procedure

In the present investigation, different actions were carried out. First, there was the selection of the educational center and the sample of participants, after a meeting with the school institution in which the necessary permits to develop the study were obtained.

In the second stage, the training phase was applied, which was composed of the teaching unit on environmental sciences, consisting of 11 sessions, in which the following contents were worked: (a) relief; (b) geodynamics; (c) hillside systems.

At the training level, the teaching unit was developed in various methodological ways, depending on the type of group. The control group used a traditional and expository method without ICT support. The teacher's role consisted of transmitting the contents in a masterful way, with their figure the only and main source of knowledge. The role of the students was passive, whose sole function was to receive the teacher's explanations and perform the proposed tasks. On the other hand, the experimental group was based on the application of innovative resources with FL. This approach allowed for ubiquitous learning, access to information at all times, and an active role of the students, who became the protagonists and builders of their knowledge. The students carried out research and development of teaching materials collaboratively, both physically and virtually. In this group, the role of the teacher was focused on creating and uploading audiovisual materials to the digital platform so that they could be viewed before the face-to-face session and in orienting students during the learning process.

The specific contents of the teaching process were approached based on the same theme for the control group and for the experimental group, but based on a different methodology. Regarding the theme of the relief within the control group, the teacher made an explanation of the different elements of the relief from the image of a mural attached to the board. In the right area of this board, the teacher wrote in chalk the definitions of the elements of the land relief and the coastal relief. The next day, they distributed a photocopied file with an image in which the students located the elements of the relief and explained the definition of the concept. On the other hand, in the experimental group, the students made an excursion to the mountainous area of the city. From a high area, they had to get a panoramic image of the city (coastal and mountainous environment) from the UAV. Subsequently, the students digitally edited the image to incorporate the names of the relief elements existing in the region: beach, isthmus, cliff, bay, mountain, hill, and plain. This image was uploaded to the classroom blog so that all students had the different versions of the rest of their classmates.

With regard to the theme of geodynamics within the control group, the teacher wrote a concept map on the board that the students had to copy in their notebook. Subsequently, the students memorized through repetition the concepts related to diastrophism, volcanism, seismic movements, weathering, erosion, and deposition. On the other hand, in the experimental group, the teacher uploaded to the classroom blog a slide show of images and videos with information about internal and external geodynamics. They also made an excursion outside the classroom to view a nearby area of the city affected by seismic movements and another coastal area that had suffered the effects of erosion. From the images recorded by the UAV, the students edited a documentary to explain the contents.

Finally, regarding the theme of the hillside systems, in the control group, the teacher distributed to the students specific notes with the external geological processes involved (lithological, climatic, structural, hydrological, topographic, and vegetation) in addition to the natural triggers (rainfall, earthquakes, volcanoes) or induced (deforestation excavations, or roads). The students memorized these contents outside of class time and carried out activities written in the notebook of the subject, such as short questions, reflection questions, description of images, and concept maps. However, in the experimental group the contents were carried out with a gamified approach by means of the "treasure hunt" technique. During this task, the students were divided into four groups, and each one would have to look for near evidence of deforestation, modification of the land by the creation of roads, geological action of the vegetation, and geological action of hydrology. From the images captured by the UAV, each group of students prepared a slide presentation dedicated to explaining to the classmates the specific characteristics of external geological processes and how they affect hillside systems.

Once the teaching unit was completed, the questionnaire was applied to collect the data of the entire process. All data were analyzed statistically in depth to extract relevant information and make

judgments that would allow both the objectives of the investigation and the establishment of relevant conclusions for the scientific community to be achieved.

3. Results

The analysis of the results begins with the descriptive data, in which the means of the control group and the experimental group are presented in each of the variables established in the study. As shown in Table 2, the means of the control group did not exceed the average of 2.5 in each of the variables. In contrast, the experimental group exceeded this mean, with the exception of student-content, student-student, and deepening, where the average was slightly below. Even so, the average offered in the experimental group in each of the study variables was higher than in the control group. The data produced by asymmetry and kurtosis reflect a normal distribution of values, since these were between ± 1.96 [78]. In addition, the standard deviation revealed values grouped in all the variables of the study, except in motivation, resolution, and ratings in the control group, and autonomy, collaboration, deepening, and ratings in the experimental group, where the opinions of the students were more dispersed. In the experimental group the kurtosis was platycurtic in all the variables, something that did not happen with the variables of the control group, where teacher-student, student-student, deepening, and class-time were leptocurtic.

Table 2. Results of the study variables in both groups (control and experimental) from the parameters of the mean (M), standard deviation (SD), skewness (S_{kw}), and kurtosis (K_{me}).

	Variables	Likert Scale n (%)				Parameters			
		None	Few	Enough	Completely	M	SD	S_{kw}	K_{me}
Control group	Motivation	8(26.7)	10(33.3)	8(26.7)	4(13.3)	2.27	1.11	0.266	-0.975
	Teacher-student	6(20)	16(53.3)	6(20)	2(6.7)	2.13	0.819	0.547	0.201
	Student-content	11(36.7)	12(40)	4(13.3)	3(10)	1.97	0.964	0.812	-0.127
	Student-student	6(20)	18(60)	4(13.3)	2(6.7)	2.07	0.785	0.796	0.993
	Autonomy	13(43.3)	14(46.7)	3(10)	0(0)	1.67	0.661	0.484	-0.620
	Collaboration	10(33.3)	13(43.3)	7(23.3)	0(0)	1.90	0.759	0.172	-1.18
	Deepening	15(50)	9(30)	4(13.3)	2(6.7)	1.77	0.935	1.04	0.223
	Resolution	8(26.7)	12(40)	4(13.3)	6(20)	2.27	1.08	0.478	-0.974
	Classtime	17(56.7)	8(26.7)	3(10)	2(6.7)	1.67	0.922	1.30	0.897
	Ratings ^a	10(33.3)	7(23.3)	10(33.3)	3(10)	2.20	1.03	0.017	-1.21
Experimental group	Motivation	2(6.9)	9(31)	9(31)	9(31)	2.86	0.953	-0.239	-0.987
	Teacher-student	5(17.2)	5(17.2)	15(51.7)	4(13.8)	2.62	0.942	-0.513	-0.534
	Student-content	7(24.1)	13(44.8)	7(24.1)	2(6.9)	2.14	0.875	0.403	-0.359
	Student-student	5(17.2)	10(34.5)	11(37.9)	3(10.3)	2.41	0.907	-0.033	-0.698
	Autonomy	6(20.7)	8(27.6)	6(20.7)	9(31)	2.62	1.14	-0.089	-1.42
	Collaboration	3(10.3)	8(27.6)	8(27.6)	10(34.5)	2.86	1.03	-0.346	-1.05
	Deepening	7(24.1)	6(20.7)	12(41.4)	4(13.8)	2.45	1.02	-0.175	-1.09
	Resolution	4(13.8)	6(20.7)	12(41.4)	7(24.1)	2.76	0.988	-0.431	-0.703
	Class-time	3(10.3)	4(13.8)	10(34.5)	12(41.4)	3.07	0.998	-0.841	-0.257
	Ratings ^a	16(20.7)	5(17.2)	11(37.9)	7(24.1)	2.66	1.07	-0.341	-1.09

^a Established grade group (None: 1-4.9; Few: 5-5.9; Enough: 6-8.9; Completely: 9-10).

The average obtained in the variables of the experimental group, where the educational experience was developed through FL, was above the variables of the control group, in which a traditional teaching method was applied. The greatest distance between variables is shown in class-time and collaboration, while the smallest distance is presented between student-content (Figure 3).

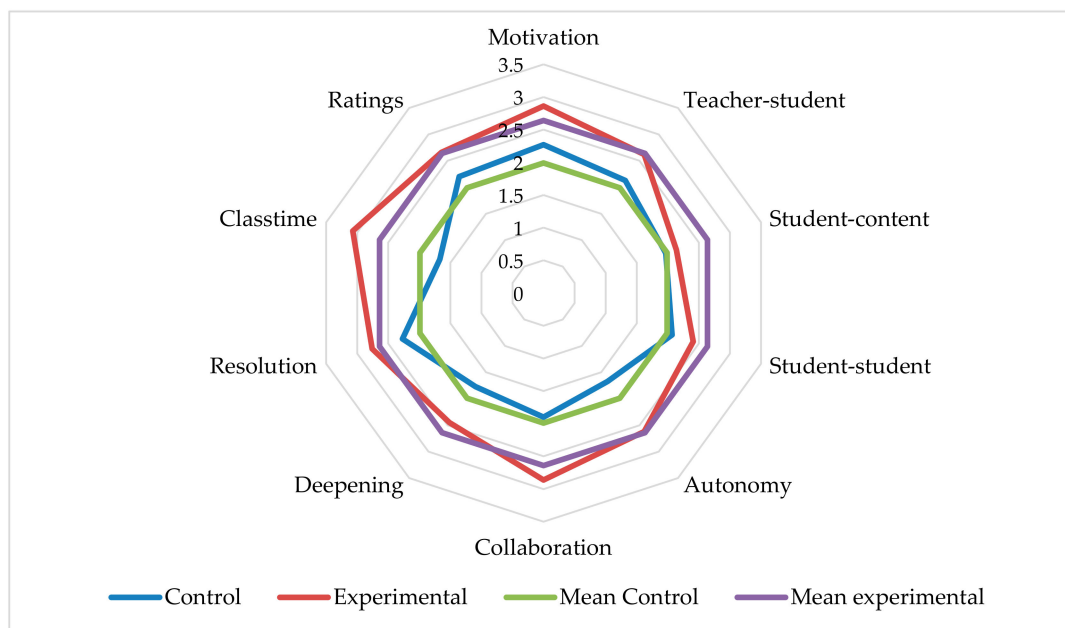


Figure 3. Comparison between control groups and experimental groups.

In the data obtained in the comparison of means established by the Student’s *t*-test for independent samples between the control group and the experimental group, it can be observed that not all variables showed significant differences, and those that established their strength of association varied. In this case, the variables with a higher level of significance were autonomy, collaboration, deepening, and class-time, with values located in the biserial correlation between 0.3 and 0.6, which shows an average association force. The motivation and teacher-student variables offered a significant relationship, although their strength of association was low. Finally, it can be seen that the variables student-content, student-student, resolution, and ratings were not statistically significant, because their *p*-values were above 0.05. In addition, with reference to the value of Cohen’s *d*, the effect size was low, since the values were between ± 1.5 (Table 3).

Table 3. Study of the value of independence between the groups (control and experimental) with the Student’s *t*-test ($t_{n1+n2-2}$), degree of freedom (*df*), the Cohen’s *d* (*d*), and biserial correlation (r_{xy}).

Variables	$\mu(X1-X2)$	$t_{n1+n2-2}$	<i>df</i>	<i>d</i>	r_{xy}
Motivation	-0.595(2.27–2.86)	-2.321*	57	0.058	0.294
Teacher-student	-0.487(2.13–2.62)	-2.123*	57	-0.114	0.271
Student-content	-0.171(1.97–2.14)	n.s.	57	0.068	0.094
Student-student	-0.347(2.07–2.41)	n.s.	57	-0.085	0.204
Autonomy	-0.954(1.67–2.62)	-3.898**	57	0.014	0.462
Collaboration	-0.962(1.90–2.86)	-4.085**	57	0.025	0.478
Deepening	-0.682(1.77–2.45)	-2.676**	57	0.060	0.334
Resolution	-0.492(2.27–2.76)	n.s.	57	-0.022	0.235
Class-time	-1.40(1.67–3.07)	-5.609**	57	0.115	0.596
Ratings ^a	-0.455(2.20–2.66)	n.s.	57	0.021	0.214

** The correlation is significant at the 0.01 level. * The correlation is significant at the 0.05 level. n.s. Not significant.

^a Established grade group (None: 1–4.9; Few: 5–5.9; Enough: 6–8.9; Completely: 9–10).

4. Discussion and Conclusions

Teaching and learning processes are undergoing changes in recent times, thanks to the phenomenon of ICTs, which are promoting innovative educational practices. Furthermore, the roles of the main agents in the training process are being transformed. Teachers are becoming learning guides and students are becoming managers of their own training [1–6]. The new technopedagogical environments

provide new learning spaces that, in turn, improve aspects such as motivation, autonomy, participation, and attitude of students. Likewise, ICTs have led to an increase in the quality of training [7–10,12–14].

Among all the educational practices associated with ICT we find the FL, which, according to impact studies of the last years, increases motivation, commitment towards the task, interactions produced between teachers and students, the acquisition of didactic contents, active and protagonist participation of the students, self-management of students' learning, the attitude of the student towards the contents, and their academic performance [29–34,36–39].

The present study focused on the use of the FL teaching method to work on contents of the subject of earth and environmental sciences in students of the second year of high school. Therefore, this research shows how the early implementation of remote sensing data provided by UAV can support learning. Based on the results achieved, it was determined that the pedagogical application improved motivation, the relationship between teacher and student, between students and content, autonomy, collaboration, deepening, resolution, class-time, and academic performance, as well as other studies reported in recent literature [15,29,45–49].

In particular, the highest incidence of the use of FL in the presented context occurred in the sensation of class-time, there being a great difference with respect to the traditional methodology. On the other hand, a minor difference was produced in the ratings, so although there was observed improvement, the incidence was minimum.

It can be concluded that the use of FL generates improvements in the teaching and learning processes of high school students for the development of environmental science content, complemented by remote sensing technology, making it an effective educational approach. This innovative methodological tool has improved student motivation within the teaching and learning process. The relational and socializing environment has also improved, establishing a greater interrelation between the group of students and creating a closer relationship with the teacher, all under collaborative learning. From this context, the use of UAV in flipped learning has allowed an increase in student autonomy, in the ability to solve problems. In the teaching perspective, this innovative methodological tool allows a greater deepening of the didactic contents and a greater use of time in the classroom to improve the academic performance of its students.

The prospective of this study was to offer the academic and scientific community an alternative for teaching this type of environmental content, combining technological resources (UAV with remote sensing) and active methodologies (FL). In addition, it was intended to highlight the benefits that this training action can generate in students, in the face of new research that contrasts the data presented here.

The main limitations found during the research process are related to the bureaucratic process to obtain the necessary administrative permits to carry out developing educational experiences with UAV. The search for teachers who had the necessary training for the use of UAV in the teaching and learning process was also complex. It should also be kept in mind when assessing the data shown that the study was developed for a specific population, so the generalization of the results obtained should be taken with caution when relating them to other educational experiences of similar characteristics.

Despite specific limitations, this study aimed to open a new path for an area of educational research that has not yet been deeply explored. Starting from the exploratory nature of the present study, it was intended that the information reflected in this research would allow the scientific community in general and the educational community in particular to reflect on the benefits and potential of UAV and remote sensing combined with the flipped learning model. Despite the positive effects that the application of technology can bring to the teaching and learning process, and flipped learning in particular, it is necessary to highlight that its use can be a bias to be taken into account in the analysis of the results of this study. The study group that followed a flipped learning methodology complemented with UAV and technology reached positive scores, but it is not possible to know the direct incidence of UAV and technology in the results obtained. The exact percentage of UAV contribution to the flipped learning methodology is unknown and we only know that the positive effects were maintained.

The pioneering studies on education give great importance to the inclusion of innovative technologies and the implementation of this type of tool is the way forward for an updated education, suitable for current students and optimized for the digital society of our century.

Thus, it is proposed that the scientific community continue to investigate the benefits of the incidence of UAV and remote sensing combined with the flipped learning methodology as an innovative and emerging resource for education. Likewise, as a future line of research, it is proposed to extend the analysis of this study to other educational contents or stages, with the intention of contrasting the results achieved in this research.

Author Contributions: Conceptualization, J.L.B., A.J.M.G. and J.A.L.N.; methodology, J.L.B.; software, A.J.M.G. and S.P.S.; validation, A.J.M.G.; formal analysis, J.L.B. and A.J.M.G.; investigation, J.L.B., A.J.M.G., J.A.L.N. and S.P.S.; data curation, J.A.L.N., J.L.B. and A.J.M.G.; writing—original draft preparation, J.L.B., A.J.M.G., J.A.L.N. and S.P.S.; writing—review and editing, J.L.B., A.J.M.G., J.A.L.N. and S.P.S.; visualization, J.A.L.N. and J.L.B.; supervision, J.A.L.N., J.L.B. and A.J.M.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We acknowledge the researchers of the research group AREA (HUM-672), which belongs to the Ministry of Education and Science of the Junta de Andalucía and is registered in the Department of Didactics and School Organization of the Faculty of Education Sciences of the University of Granada.

Conflicts of Interest: The authors declare no conflict of interest.

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