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E-Learning in the Teaching of Mathematics: An Educational Experience in Adult High School

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Abstract: Currently, the e-learning method, due to the period of confinement that is occurring due to COVID-19, has increased its use and application in the teaching and learning processes. The main objective of this research is to identify the effectiveness of the e-learning method in the teaching of mathematics with adults who are in high school, in contrast to the traditional expository method. The study developed is quantitative, descriptive and correlational. The research design is quasi-experimental, with a control group and an experimental group. The results show that the use of the e-learning method has a positive influence on motivation, autonomy, participation, mathematical concepts, results and grades. It can be concluded that the e-learning method leads to improvement in adult students who are studying the mathematical subject in the educational stage of high school, provided that it is compared with the expository method. Therefore, this method is considered effective for its implementation in adults.

Keywords: emerging methodology; educational innovation; e-learning; educational experimentation; adults; students

1. Introduction

Technological development is a reality today [1]. This fact is reflected in our society [2], specifically in the labour, social and educational fields [3]. This technological advance facilitates, strengthens and speeds up the performance of daily tasks [4].

In the educational field, technological progress is reflected in the development of the so-called information and communication technologies (ICT) [5]. ICTs directly influence the development of teaching and learning processes [6], since they promote innovative pedagogical actions, as well as generate new learning spaces [7]. These pedagogical events enhance the transformation of the classroom as we know it [8], since they allow for the elimination of spatial-temporal barriers [9], as well as access to a large amount of information [10], with different formats [11]. It has also promoted the improvement of students' motivation, autonomy, involvement and attitude towards educational content [12–14].

Among the pedagogical actions based on ICTs is e-learning, which is defined as the pedagogical act that takes place online, thanks to the use of the Internet and technological devices, whether mobile or not, with synchronous or asynchronous connection, and from anywhere [15]. Therefore, the e-learning method becomes a pedagogical tool that facilitates access to learning for the whole of society [16].

The method of not is of recent creation [17], since its beginnings date back to 1993, when it began to be used more assiduously, having a greater impact in the field of education [18]. Prior to that date, distance learning was widely used.

This method of teaching is currently on the rise due to COVID-19 [19]. Its flexibility in terms of location, time, effort and costs [20], makes it the most appropriate option for training and evaluating students [21].

It should be borne in mind that two types of resources are required to develop the e-learning method: digital and technological [22]. Among the digital resources are educational videos, teaching platforms, videoconferences, podcasts, social networks, among many other resources [23]. While technological resources can be the desktop computer, tablet, smartphone, among others [24].

The use of e-learning by the members involved in the teaching and learning process becomes a challenge [17], because an average level of digital competence is required to apply it with guarantees [25]. Therefore, teachers and students need to be trained in the use of the various technological and digital resources [26].

This teaching method has a number of characteristics that make it different from other teaching methods [27]. Some authors see it as an evolution of distance education [28,29]. For others, it is a new teaching modality that differs substantially from face-to-face teaching [30].

Be that as it may, e-learning has a number of characteristics, among which are promoting dialogue and group activities, enhancing students' interpersonal relations [31]; encouraging collaboration among students themselves, achieving joint goals in the elaboration of different tasks [29]; facilitating communication, both synchronous and asynchronous [32]; enabling learning to take place from any location, provided that a technological device is available [33] to encourage the acquisition of digital competence in students [34]; enable adaptation to the individual pace of students [35]; enhance motivation, as the student can develop his or her own learning style [36]; promote the acquisition of learning to learn competence [37]; be adapted to the circumstances of each individual, both personal and occupational [38]; provide access to an unlimited amount of learning resources [39]; facilitate teacher monitoring of student activity [40]; and promote student familiarisation with the use of technological and digital resources [41].

It should also be noted that the e-learning method is a special case of distance learning [42]. There are several reasons for this [43]. In distance learning, email is used to receive the contents of the subject, not having a virtual medium [44]. In addition, a large number of theoretical contents are presented, which are not interactive and whose sequencing is closed [45]. Additionally, contact with the teacher is sporadic, which acts as a mere transmitter of content. In this case, the student is a passive receiver, who usually has a feeling of loneliness [46].

In other words, the teaching-learning process can take place 24 hours per day, every day of the year [47], allowing students to be trained while they are on the move or in a place other than their usual one [48], promoting a change in the teacher-learner mentality, and with it the philosophy of learning, in which the student organizes his or her training process and the teacher guides that action [49], and allowing unlimited access to network resources [50]. Therefore, the use of e-learning totally changes the perspective we had of teaching until now [51].

However, the e-learning method can generate a spatial and temporal gap [52], so it is necessary to personalize the educational experience of the students, trying to keep the learners motivated and committed [53]. Moreover, in developing countries, the use of ICT is not as widespread as in developed countries, leading to a lack of acceptance of technological resources and, therefore, of e-learning, not having the desired effect on educational learning [54,55].

Mathematics in the field of social sciences is considered a necessary instrument to be able to decipher the closest environment and represent various facts, be they social, scientific and technical that occur in today's world [56]. Mathematics facilitate the understanding of various phenomena, be it social reality itself, economic aspects or historical facts, among others [57]. In this case, mathematics becomes an adequate tool to acquire knowledge, reflect on social aspects, and represent facts from the environment [58]. In other words, mathematics tries to convert all these facts into knowledge and information [59]. In addition, the language used in the mathematical field allows the phenomena that occur to be explained in detail and precisely [60].

It should be borne in mind that mathematics is instrumental, and is the basis for acquiring knowledge from other subjects, or in other fields, such as sociology or political science [61].

In addition, mathematics develops the student's intellect, promoting competencies that will allow him to function personally and socially [62]. It also promotes creativity, the development of autonomy, the improvement of self-esteem and entrepreneurship [63].

In the field of mathematics, there are educational actions in which e-learning has been developed as a teaching method [64,65]. One of the ideas is that applied in the MCIEC model (motivation, context, interactivity, evaluation and connectivity), which entails greater student involvement. This model allows the student to increase his or her ability to make an effort to understand mathematical content, thanks to increased interest, motivation and adaptation to the context [64]. The development of the e-learning method presents improvements if it is applied with an appropriate teaching and learning method. An example of this is the development of the e-learning method associated with the GeoGebra resource, which is integrated into the Moodle platform, improving aspects related to assessment, motivation and student interest. It also promotes learning in a more meaningful way and adapts assessment to students' needs [65]. Another similar case is that of the Working Memory Capacity (WMC) method, developed in the e-learning method. This method leads to an improvement in students' abilities to acquire various mathematical concepts. In this case, it improves students' academic performance. This is due to the increase of their involvement and motivation in mathematical contents [66]. Another case is the development of the e-learning method, associated with the Edmodo application, in the field of mathematics. This training process increases participation in learning. This involvement increases the memorization, comprehension, application, analysis, evaluation and creation of mathematical contents. It also increases students' attitude and acceptance of mathematical content [67]. The use of e-learning in the development of mathematics increases the commitment of students themselves, improving performance. It also increases interest, and thus, acquired results. It also improves the acquisition of mathematical content [68]. Another example is pedagogical action, in which e-learning is used with the individualized e-learning environment called UZWEBMAT. This combination promotes individualized attention of students. Moreover, it is adapted to the learning style of the students, improving their comprehension skills. It also increases their responsibility for learning and is reflected in motivation and academic performance [69]. In many cases, student learning, and therefore student outcomes, can be affected by poor connectivity, inflexible scheduling, and inadequate devices [70].

2. Justification and Research Objectives

The use of ICTs today, coupled with the global crisis being experienced by COVID-19, makes e-learning a necessary teaching method. This implies the application of new didactic strategies and pedagogical approaches [71].

This study presents a teaching method based on e-learning for adult students who study high school in the distance mode. In addition, it shows the pedagogical actions developed during the first quarter of the 2019–2020 school year. A contrast is also established with the traditional expository method developed with the students of the night school. All of this was done in the subject of mathematics applied to the social sciences.

The aim of this research is to give continuity to the application of the e-learning method in the teaching of mathematics, with the intention of contrasting the results obtained in other studies with similar characteristics [63–70].

The main objective of this research is to identify the effectiveness of the e-learning method in teaching mathematics to adults who are in high school, in contrast to the traditional expository method. The following specific objectives are established from this objective:

- Determine the degree of motivation;
- Identify the degree of autonomy;
- Analyse the level of collaboration;

- To know the degree of participation;
- To find out the level of problem solving;
- Determine the degree of class time;
- Identify the level of learning of concepts, graphs, scientific data and results;
- To know the capacity of decision in the pedagogical actions; and
- To find out the variation of grades.

3. Method of Investigation

3.1. Research Design and Data Analysis

The study developed is quantitative, descriptive and correlational [72]. The research design is quasi-experimental, with a control group (GC) and an experimental group (Ge), that is, non-equivalent groups. In this case, the research process developed in other previous studies has been followed, where active teaching methods have been applied [73,74]. Unlike the investigations mentioned above, this study tries to know how an active teaching method influences, in this case, the e-learning method in the development of the development of the subject of mathematics. For this, a contrast is established with the exhibition method. The students are divided into two groups: the control group, made up of night school freshmen; and the experimental group, made up of distance school freshmen. In both groups the subject of mathematics applied to social sciences has been developed. In the control group the traditional expository method has been applied. In the experimental group the e-learning teaching method has been developed. The distribution of the students has not been random, because the groups have been formed by the head of studies, according to the registration requested by the students. The criteria for the distribution of the student body is based on the principles of equity and equality. In other words, the management team distributed the groups bearing in mind several criteria, including the length of time the students have been out of official studies and the grades of the last year enrolled. With respect to years of non-study, it established three criteria: (a) more than 10 years not enrolled in official studies; (b) between 10 and 5 years not enrolled in official studies; (c) less than five years not enrolled in official studies. With regard to the qualification, it established four criteria: (a) no subjects passed in the last year enrolled; (b) between 0 and 3 subjects passed; (c) between 4 and 6 subjects passed; (d) all subjects passed. Based on these criteria, it made an even distribution. These criteria are set out in the School Education Project. The information was collected at the end of the first quarter, that is, after the pedagogical intervention, through the application of a post-test (Table 1).

Table 1. Composition of the groups.

Group	*n*	Composition	Pretest	Treatment	Posttest
1- Control	61	Natural	-	X_1	O_1
2- Experimental	71	Natural	-	X_2	O_2

The Statistical Package for the Social Sciences (SPSS) v25 (IBM Corp., Armonk, NY, USA) was used to analyse the data collected. The statistics used are mean (M) and standard deviation, in addition to skewness (S_{kw}) and kurtosis (K_{me}) statistics. Additionally, Student's t-test ($t_{n1+n2-2}$) has been used to compare the means between the established groups. Finally, Cohen's d-test and the biserial correlation (r_{xy}) have been applied, in order to know the effect size and the out-of-association. The significance level applied in the study was $p < 0.05$.

3.2. Participants

The sample applied in this research consists of 132 students. The sampling technique applied is for convenience. This is due to the ease of access to the students. In studies focused on the application of pedagogical methods, the sample size is not a determining factor [75,76].

The students are studying the first year of the adult baccalaureate, specifically the humanities and social sciences, at an adult education centre in Southern Spain. There is a total of 39.39% men and 60.61% women, with an age range between 18 and 33 years old (M = 23.3; SD = 1.89), where 40.15% have work, and 35.61% have family responsibilities.

The research was conducted in the first quarter of the 2019–2020 school year. Previously, permission was requested from both the school management and the students themselves. Both were informed of the objectives of the research. Neither the school nor the students refused to participate.

3.3. Instrument

The instrument used is an ad hoc questionnaire that has had as reference the questionnaires 77 and 78, which consists of 30 items (Appendix A). These are distributed in different dimensions: Socioeducational (five items), oriented to know the socio-educational aspects of the sample; motivation (two items), autonomy (two items); collaboration (two items); participation (two items); resolution (two items); class time (two items), in which the aim is to identify the attitudes, motivations and interests of the student in the application of the teaching method; concepts (two items), scientific data (two items), graphics (two items), results (two items), decision (two items), ratings (three items), which focus on the learning acquired in the subject of mathematics. In addition, teacher-ratings have been taken into account, obtaining the values of the grades established by the teacher. The questionnaire uses a Likert scale, composed of four items (1: None, 2: Few, 3: Enough and 4: Completely).

This questionnaire has been subjected to various statistical tests, for its validation and reliability. At first, the Delphi method was used, with qualitative validity, by eight experts, whose ratings were positive (M = 4.66; SD = 0.16; min = 1; max = 6). Then, the statisticians of Kappa de Fleiss and W de Kendall were used, whose results were adequate (K = 0.89; W = 0.87). Subsequently, it was validated through exploratory factor analysis with varimax rotation, whose data (Bartlett = 2981.09; $p < 0.001$; Kaiser-Meyer-Olkin = 0.89) are adequate. It was finalized using Cronbach's alpha (0.91), McDonald's omega method (0.89), compound reliability (0.85) and mean variance extracted (0.84), showing adequate metrics. Taking into account the statistical tests, the instrument is considered as valid and reliable. The internal consistency of each of the dimensions is: Socio-educational (0.941); motivation (0.884); autonomy (0.861); collaboration (0.952); participation (0.891); resolution (0.948); class time (0.923); concepts (0.891); scientific data (0.901); graphics (0.912); results (0.884); decision (0.896); and ratings (0.911).

3.4. Dimensions and Study Variables

The study focuses research on attitudes and mathematical development. Both aspects have marked the distribution and composition of the dimensions of this study [77,78].

In addition, the dependent and independent variables have been established. The dependent variables are associated with the dimensions indicated for this study. The teaching method developed during this research is established as the independent variable. In order to facilitate the understanding of the results achieved, each of the dimensions is analysed:

- Motivation: Identifies the level of motivation achieved by students in the development of the teaching and learning process;
- Autonomy: Shows the level of autonomy of the student in the development of the tasks posed;
- Collaboration: Shows the ability to work with other colleagues in the development of the task;
- Participation: It identifies the level of involvement and relationship of the student with the contents, with the teacher and with his/her fellow students;
- Resolution: It shows the student's capacity to give an answer to possible problems that may arise in the performance of class activities;
- Class time: It analyses the feeling of time that the student has in the process of teaching and learning;

- Concepts: Identifies the level of acquisition, according to the student, of the contents applied in the pedagogical act;
- Scientific data: Presents the scientific aspects, typical of the mathematics subject, reached by the students;
- Graphics: It gathers the aspects related to the different mathematical graphs developed during the formative period;
- Results: It shows the different actions and mathematical problems developed in the realization of the contents;
- Decisions: Presents the common actions used by the students in order to solve possible activities;
- Ratings: It offers the students' self-evaluation in the teaching and learning process; and
- Teacher-ratings: Presents the qualification given by the teacher to the students in the pedagogical act. In this case, the qualification criteria are taken into account.

3.5. Methodological Procedure

The research process developed began with the validation and reliability of the instrument used. Subsequently, the selection of the sample and the application for permits were made. In this case, the pedagogical proposal was presented to the selected school, which agreed to participate. The centre, itself, requested information on the results achieved in the research.

Then, the pedagogical proposals were developed. On the one hand, the traditional exposition method (Gc), in which the teacher presented the theoretical contents, followed the sequence of the textbook and proposed tasks. On the other hand, there is the e-learning method (Ge), which will be explained in more detail in the next point.

At the end of the first quarter, data was collected using Google Form, which is a Google Drive tool. In other words, the data was collected on the last day of class, in the auditorium of the educational centre, which has a capacity for 300 people. To do this, the students used their own mobile devices. In the cases that they did not have, the centre gave them one to fill out the questionnaire. Indicate that the data collection was carried out at the same time, specifically at 18:10. This data was downloaded in Excel format and transcribed into the format of the selected statistical program. Finally, the various statistical tests were carried out and the results obtained were analysed.

3.6. Pedagogic Procedure

The pedagogical proposal developed with the experimental group is based on the e-learning method. For this purpose, the teacher has made use of the Moodle platform and e-mail. In addition, every week, a schedule was established, consisting of one hour of group attention and two hours of individualized attention. The three hours could be developed in a face-to-face way in the educational centre. It should be noted that these hours were not compulsory. Only those students who considered it necessary came to the centre, and on a voluntary basis. It should be noted that during the study procedure, hardly any students attended the centre to answer questions. The group that developed the expository method, had an hour of tutoring with the teacher of the subject, to solve doubts individually, or attend to the concerns of the students. During this period, the teacher also attended to the student through a virtual platform and by e-mail.

The Moodle platform contained all the content to be dealt with in the subject during the first term, distributed by didactic units. In this case, four didactic units were established for the first quarter. Each one of the didactic units of the Moodle platform was structured in different sections:

- Theory: Formed by theoretical aspects of the subject, presented in pdf format and explanatory videos. The intention was to present all the theoretical aspects of the contents to be worked on, and to reinforce their acquisition through the viewing of videos related to these contents;
- Practice: Composed of activities to show the acquisition of the theoretical contents. These activities were of introduction, development, consolidation, extension and reinforcement. The activities

have been varied, having different types: short answer, long answer, assumptions, problem solving and autocomplete, relate columns and operations, among others. In this case, all the tools available in Moodle have been used;

- To know more. In this section students have been allowed to go deeper into the contents of the subject. This was done through links to web pages on the subject. There were also links to games related to the contents worked on; and
- Forum: This resource has been used in each didactic unit. The intention was to establish a debate, both with the teacher and with other colleagues, on the contents dealt with in the subject. In addition, it has served to resolve doubts and pose small riddles related to the aspects worked on.

The evaluation methods and instruments used have been:

- Written test (50% of the quarterly mark): This test was taken at the end of the quarter. The types of questions were short answer and long answer; and
- Systematic observation (50% of the quarterly mark): Participation in the forum and the development of the activities set out in the Moodle platform were analysed. The instrument used was a heading.

On the other hand, the pedagogical proposal developed by the control group was based on the presentation of theoretical contents by the teacher. In addition, activities have been developed, both from the textbook and from cards given by the teacher. As a method and instrument of evaluation, the following have been applied:

- Written test (50% of the quarterly mark): This test was taken at the end of the quarter. The question type was short answer and long answer; and
- Systematic observation (50% of the quarterly mark): The development and elaboration of the activities proposed by the teacher were analysed. The instrument used was a heading.

4. Results

The data presented in Table 2, after the descriptive statistical analysis, show diversity of response among students who attend both the night school and the distance school. According to the data provided by the asymmetry and kurtosis statisticians, the response distribution is considered normal. This is because the values are between ±1.96, according to [79]. The students in the control group show a mean response that is around 2. Some dimensions are slightly below and others are slightly above. In the control group the dimension with the highest rating is resolution. In contrast, the dimension with the lowest rating is decision. The students in the experimental group show a response tendency that is around 2.5 points. The least valued dimension in the experimental group is decision. The most valued dimension in the experimental group is teacher-ratings. According to the statistic that shows the standard deviation, an even trend of response is observed in the students. This is presented in all the dimensions of the study, both in the control group and in the experimental group. Kurtosis is platykurtic in all study dimensions, both in the control group and in the experimental group.

Table 2. Results obtained for the dimensions of study in GC and EG of high school students.

		Likert Scale *n* (%)				Parameters			
	Dimensions	**None**	**Few**	**Enough**	**Completely**	**M**	**SD**	S_{kw}	K_{me}
Control group	Motivation	24(39.3)	19(31.1)	14(23)	4(6.6)	1.97	0.948	0.552	−0.757
	Autonomy	26(42.6)	17(27.9)	13(21.3)	5(8.2)	1.95	0.990	0.633	−0.760
	Collaboration	20(32.8)	19(31.1)	16(26.2)	6(9.8)	2.13	0.991	0.366	−0.961
	Participation	23(37.7)	22(36.1)	13(21.3)	3(4.9)	1.93	0.892	0.568	−0.569
	Resolution	13(21.3)	16(26.2)	24(39.3)	8(13.1)	2.44	0.975	−0.112	−0.990
	Class time	23(37.7)	19(31.1)	13(21.3)	6(9.8)	2.03	0.999	0.554	−0.804
	Concepts	21(34.4)	19(31.1)	15(24.6)	6(9.8)	2.10	0.995	0.427	−0.921
	Scientific data	26(42.6)	18(29.5)	13(21.3)	4(6.6)	1.92	0.954	0.644	−0.676
	Graphics	24(39.3)	18(29.5)	15(24.6)	4(6.6)	1.98	0.957	0.505	−0.862
	Results	18(29.5)	23(37.7)	13(21.3)	7(11.5)	2.15	0.980	0.462	−0.753
	Decision	28(45.9)	17(27.9)	14(23)	2(3.3)	1.84	0.898	0.620	−0.796
	Ratings [a]	21(34.4)	19(31.1)	16(26.2)	5(8.2)	2.08	0.971	0.396	−0.924
	Teacher ratings [a]	12(19.7)	23(37.7)	17(27.9)	9(14.8)	2.38	0.969	0.190	−0.886
Experimental group	Motivation	6(8.5)	20(28.2)	24(33.8)	21(29.6)	2.85	0.951	−0.296	−0.904
	Autonomy	8(11.3)	11(15.5)	27(38)	25(35.2)	2.97	0.985	−0.680	−0.551
	Collaboration	18(25.4)	24(33.8)	21(29.6)	8(11.3)	2.27	0.970	0.205	−0.994
	Participation	7(9.9)	16(22.5)	25(35.2)	23(32.4)	2.90	0.973	−0.467	−0.782
	Resolution	9(12.7)	19(26.8)	24(33.8)	19(26.8)	2.75	0.996	−0.268	−0.972
	Class time	15(21.1)	32(45.1)	12(16.9)	12(16.9)	2.30	0.991	0.455	−0.768
	Concepts	7(9.9)	16(22.5)	24(33.8)	24(33.8)	2.92	0.982	−0.479	−0.881
	Scientific data	18(25.4)	27(38)	16(22.5)	10(14.1)	2.25	0.996	0.358	−0.878
	Graphics	16(22.5)	29(40.8)	15(21.1)	11(15.5)	2.30	0.991	0.364	−0.847
	Results	5(7)	19(26.8)	21(29.6)	26(36.6)	2.96	0.963	−0.408	−0.956
	Decision	24(33.8)	26(36.6)	13(18.3)	8(11.3)	2.07	0.990	0.582	−0.671
	Ratings [a]	7(9.9)	16(22.5)	23(32.4)	25(35.2)	2.93	0.990	−0.492	−0.838
	Teacher ratings [a]	5(7)	16(22.5)	23(32.4)	27(38)	3.01	0.949	−0.545	−0.736

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

The means presented by the control group and the experimental group show relevant differences. In the control group, there is diversity of means between the study dimensions. The resolution and teacher-ratings dimensions stand out from the total mean. On the other hand, the decision dimension is much lower than the mean. In the experimental group, these differences are more pressing. In this case, the dimensions motivation, autonomy, participation, resolution, concepts, results, ratings and teacher ratings are located above the mean. On the other hand, the collaboration, class time, scientific-data, graphics and decision dimensions are located far below the totalised mean. Furthermore, even ratings are observed, both in the control group and in the experimental group, in the collaboration, class time, scientific-data, graphics and decision dimensions (Figure 1).

To identify the value of independence between the expository-traditional method and the e-learning method, Student's t statistical test has been used. The values present higher averages in favour of the experimental group, although it is not significant in all cases. The dimensions motivation, autonomy, participation, concepts, results, ratings and teacher-ratings show a significant relationship. In all the dimensions where there is a relationship of significance, the force of association is average, if the values of the biserial correlation are taken into account. The size of the effect is low in class time and graphics, and very low in the rest of the dimensions (Table 3).

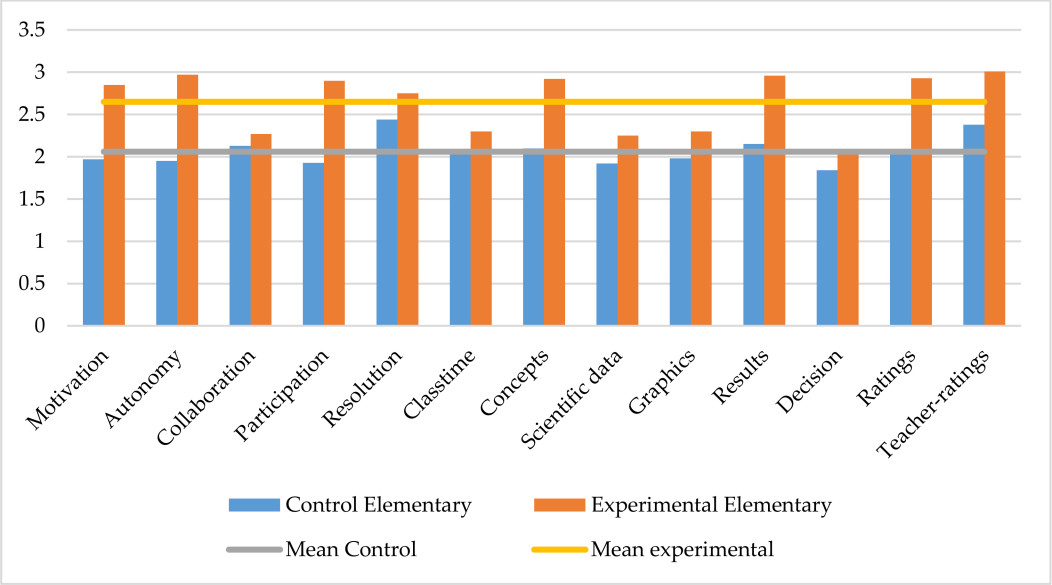

Figure 1. Comparison between control group and experimental group.

Table 3. Study of the value of independence between control group and experimental group.

Dimensions	μ(X1−X2)	$t_{n1+n2-2}$	df	*d*	r_{xy}
Motivation	−0.878 (1.97−2.85)	−5.295 **	130	0.094	0.421
Autonomy	−1.021 (1.95−2.97)	−5.922 **	130	0.062	0.461
Collaboration	−0.136 (2.13−2.27)	−0.798	130	0.036	0.070
Participation	−0.967 (1.93−2.90)	−5.914 **	130	0.048	0.460
Resolution	−0.304 (2.44−2.75)	−1.765	130	0.029	0.153
Class time	−0.263 (2.03−2.30)	−1.514	130	0.115	0.132
Concepts	−0.817 (2.10−2.92)	−4.737 **	130	0.052	0.384
Scientific data	−0.335 (1.92−2.25)	−1.967	130	0.097	0.170
Graphics	−0.312 (1.98−2.30)	−1.833	130	0.105	0.159
Results	−0.810 (2.15−2.96)	−4.780 **	130	0.038	0.387
Decision	−0.234 (1.84−2.07)	−1.415	130	0.081	0.123
Ratings [a]	−0.848 (2.08-2.93)	−4.947 **	130	0.052	0.398
Teacher ratings [a]	−0.637 (2.38−3.01)	−3.809 **	130	−0.008	0.317

**. The correlation is significant at the level 0.01. [a]. Established grade group (None: 1–4.9; Few: 5–5.9; Enough: 6–8.9; Completely: 9–10).

5. Discussion

The rise of information and communication technologies, related to the current situation of confinement caused by COVID-19, makes the e-learning method relevant in recent times, thus promoting innovative educational practices [1–6].

The e-learning teaching method breaks with the classic stereotypes of teaching and learning processes, since it modifies the spaces and time of training, allowing the development of the pedagogical act in any place and at any time. This can be achieved if technological devices and digital resources are available, as well as internet access [22–27].

In the present research, the influence of e-learning in the field of mathematics has been analysed, in contrast to the traditional expository method, in adult students who are studying for high school. As shown in the results obtained, there are significant differences between the values achieved in the control group and the experimental group. These differences have always been in favour of the e-learning method.

In the group where the expository method has been developed, the lowest values have been produced in the decision. In this case, students have difficulties in making decisions by themselves

when solving the proposed mathematical problems. On the other hand, the most valued dimension is the resolution, that is, the carrying out of activities in class. This may be due to the fact that the teacher, present in the expository method, can respond to the needs that the students may have during the development of the different practices.

In the group where the e-learning method is developed the dimension with the highest score is teacher-rating. This shows that the students' grades are increasing, being in line with [58]. On the other hand, the less valued dimension, as in the control group, is decision. In other words, neither the expository-traditional method nor the e-learning method allows the student's decision-making to improve when it comes to solving a problem on their own.

Both in the control group and in the experimental group, students have shown a tendency to respond evenly. This shows that the students agree on the teaching methods applied. This does not mean that there are equal values in all the study dimensions. In the control group the means of the dimensions have not been equal to each other. Examples of this are the dimensions resolution and teacher-ratings, which are above the totalised mean. That is to say, for the students who have developed the expository method, in these dimensions, they show a better evaluation. On the other hand, the decision dimension is much lower than the average.

Something similar occurs in the experimental group. The averages thrown between the different dimensions are not equal to each other. In this case, the contrasts are more relevant. For example, the dimensions motivation, autonomy, participation, resolution, concepts, results, ratings and teacher ratings are above the total average. On the other hand, the collaboration, class time, scientific-data, graphics and decision dimensions are much lower than the total average.

If the means of the control group and the experimental group are compared, there are dimensions in which there are no significant differences. This is the case of the collaboration, class time, scientific-data, graphics and decision dimensions, which present evenly distributed means, although always with higher values in the experimental group.

Where there are significant differences, in favour of the e-learning method, are in the dimensions of motivation [36,59], autonomy [35], participation [60], concepts [55], results, ratings and teacher ratings [58]. In other words, the e-learning method favours these aspects in the pedagogical act.

In the dimension where there is a greater contrast, when comparing the expository-traditional method with the e-learning method, it is in autonomy. This may be mainly due to the fact that the e-learning method favours self-regulation of learning [39].

If this study is compared with other studies in which e-learning has been developed, improvements in students can be observed. On the one hand, there is an improvement in motivation, autonomy, participation, concepts, results and grades. All these aspects are reflected in other studies, in which the e-learning method is associated with a clearly defined and structured pedagogical approach. In the studies analysed, student effort, which has an impact on their qualifications, is due to increased motivation and interest. In other words, the pedagogical approach influences whether the student can be more or less motivated. In addition, the fact that the student is more motivated leads to an increase in participation, which will lead to improvements in the acquisition of mathematical concepts. It will also influence the resolution of various activities. All of this is ultimately reflected in the grades, which increase. Therefore, it can be indicated that there is an improvement in students' academic performance. Furthermore, it should be taken into account that the e-learning method will favour the autonomy of the student, adapting to his or her learning style, which implies more individualised attention to the teaching and learning process. What is clear from all this research is that the e-learning method is associated with a clearly defined pedagogical process, as shown in this research [64–70].

6. Conclusions

In general, it can be indicated that the dimensions of motivation, autonomy, participation, concepts, results, self-evaluation and teacher qualification have proved to be significant. That is to say, according to the study group, differences are observed in the evaluations given by the students. It should be

borne in mind that these differences may be motivated by the application of the teaching method applied. In one group the expository method has been developed and in the other the e-learning method. The most valued dimensions have been those of the group in which the e-learning method has been developed. This can be due to several reasons. One of them is the applied method, since the e-learning method makes the student the guide of his/her own learning. That is, they have more weight in the teaching and learning process, while the teacher is a guide. This aspect can have a direct influence on motivation, autonomy and participation. This fact, in turn, can lead to a better acquisition of mathematical concepts and results, given that being motivated and having more autonomy in learning, allows the student to increase his or her participation, and in his or her view, to present more interest in the contents being developed. Finally, the improvement in the concepts and results generates an improvement in the qualification of the students, and therefore, an improvement in the self-evaluation of the didactic actions developed. The rest of the dimensions, such as collaboration, resolution, class time, scientific data, graphics and decision, no differences were observed. This may be due to the method itself. In this case, both the e-learning method and the expository method, due to their didactic processes, do not require greater collaboration among students, nor in the feeling of class time. The other dimensions may be due to the fact that neither the expository method nor the e-learning method lead to an increase in the understanding and development of scientific data, the development of graphs or decision-making.

It can be concluded that the e-learning method is an improvement for adult students who are studying mathematics in the educational stage of high school, provided that it is compared with the expository method. In this case, the improvements occur in motivation, autonomy, participation, concepts, results, ratings and teacher-ratings. Therefore, the use of the e-learning method would be effective for its implementation with adults who study mathematics in high school.

The prospective of the research is based on two aspects. On the one hand, the aim is to present the scientific community with new data on the application of innovative teaching methods. In this case, the e-learning method is compared with the traditional expository method for teaching mathematics to adults studying in secondary schools. On the other hand, the aim is to publicise the educational practice developed in this research, so that other teachers, in similar circumstances, can develop it.

The limitations of the study are several. On the one hand, the study sample presents some specific socio-educational characteristics, so one must be cautious when extrapolating the data to other populations. The access to the sample has been for convenience, due to the fact that the educational groups are established by the educational centres themselves. This has prevented the application of other sampling techniques. Finally, the fact of not applying a pretest and posttest study process makes it impossible to be categorical in ensuring that the e-learning method directly influences the dimensions, since there may be other elements that may have been include in the development of the study. Therefore, the results obtained should be treated with caution.

As a future line of research, it is presented to develop this didactic method in other educational stages and in other educational subjects.

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Appendix A

Table A1. The instrument used is an ad hoc questionnaire.

Socio-Educational Dimension					
Variable	Item	Choice			
Gender	Gender	Man Woman			
Age	Age	18–19 years 20–21 years 22–23 years 24 or more years			
Religion	Religion	Christian Muslim Jewish Hindu Atheist Other			
ICT use frequency	How much time do you spend using ICTs every day?	From 0 to 2 h a day From 2 to 4 h a day More than 4 h a day			
Context	What is your socioeconomic level?	Low Level Medium level High level			
Dimensions	Variable	Gradation			
		1	2	3	4
Motivation	Does the methodology applied affect your motivation with regard to mathematical content? To what extent has the methodology applied improved your motivation with regard to mathematical content?				
Autonomy	How does the methodology applied in the field of mathematics contribute to their autonomy?				
	To what extent has the methodology applied in the field of mathematics contributed to their autonomy?				
Collaboration	How does the methodology developed in the subject of mathematics affect the collaboration of the group? To what extent has the methodology applied in the subject of mathematics contributed to the collaboration of group's collaboration?				
Participation	How has the methodology applied in the field of mathematics contributed to their level of participation? Has the methodology applied to their level of involvement in the subject of mathematics increased?				
Resolution	How does the methodology developed in the field of mathematics affect the resolution of problems that arise during the study? To what extent does the methodology applied in the subject of mathematics contribute to your ability to solve the problems that arise during the study?				
Class-time	How does the methodology developed in the field of mathematics affect the feeling of class time? Do you feel that time passes more quickly in math with the methodology applied?				
Concepts	How does the methodology developed in the subject of mathematics to learning scientific language and mathematical concepts? To what extent has the methodology applied in the field of mathematics contributed to your knowledge of scientific language and mathematical concepts?				
Scientific data	How does methodology applied in the subject of mathematics affect the use of scientific data and processes? To what extent has the methodology applied in the subject of mathematics contributed to the use of data and scientific processes?				

Table A1. *Cont.*

Socio-Educational Dimension		
Graphics	How does the methodology applied in the subject of mathematics affect the ability to analyse and represent graphs?	
	How much has the methodology applied in the subject of mathematics contributed to your ability to analyse and represent graphs?	
Results	How does the methodology applied in the subject of mathematics affect the ability to interpret and reflect the results of the proposed activities?	
	To what extent has the methodology applied in the subject of mathematics contributed to your ability to interpret and reflect the results of the proposed activities?	
Decision	How does the methodology applied in the subject of mathematics to the development of mathematical competence?	
	To what extent has the methodology applied in the subject of mathematics contributed to your ability to make decisions?	
Ratings	What is your average grade in general?	0–4.9 5–5.9 6–8.9 9–10
	What is your general average in the Mathematics subject?	0–4.9 5–5.9 6–8.9 9–10
	What has been the grade you have obtained in the Mathematics subject after the development of the experience?	0–4.9 5–5.9 6–8.9 9–10

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