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Implementation and Didactic Validation of STEM Workshops in Primary Education

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Abstract

Several studies have analyzed the emotions experienced by students in the primary education stage (6-12 years), revealing positive results in students of this age. This is relevant to begin to build from these levels an effective STEM (Science, Technology, Engineering and Mathematics) education, which allows a motivating and meaningful learning in the students. The general objective of this research is to implement and validate from a didactic point of view the use of STEM workshops in the primary classroom. For this purpose, a quasi-experimental research design has been followed with control groups, experimental groups, pre-test and post-test. Specifically, several parallel studies have been carried out in various schools. The control groups worked with a traditional methodology and the experimental groups with an active methodology with STEM workshops. In particular, a sample of 234 students between the ages of 9 and 12 has been used, divided into control groups and experimental groups. Questionnaires used as pre-test and post-test were designed as measuring instruments depending on the selected theme in each group. The results obtained in the pre-tests show the existence of low initial knowledge in the contents under study. However, after the execution of the different didactic interventions, there can be found an evolution both in the cognitive and affective domain in the students. In addition, an intergroup comparison has been carried out, which has revealed that the students who worked with STEM workshops scored better in the post-test than the students in the control group. These results allow us to conclude that this type of practical and hands-on experiences in the primary education classroom contribute to improving the teaching-learning of scientific areas in this group, both from the learning point of view and from the attitudinal and emotional point of view.

Keywords: *Primary education, STEM, Workshops, active methodologies;*

1. Introduction

Many state trusts worldwide have developed programs and strategies designed to improve the overall quality of STEM (Science, Technology, Engineering and Mathematics) education [1]. One of the objectives of strengthening STEM education at different educational levels is to foster scientific-technological vocations in students of all ages, so that they respond to the technological demands of the 21st century [2]. To reinforce interest in STEM areas, integrated activities are being developed in schools that promote discovery and innovation both within the school curriculum and through extracurricular programs with STEM activities and programs [3,4]. STEM education programs encourage students to make new and productive connections through interdisciplinary integration, resulting in better learning, greater interest and commitment [5]. In order to transmit an adequate conception about STEM areas, it is essential to include in the didactic programming the realization of manipulative works [6]. However, it is the teachers, both primary and secondary, who must also be prepared to offer this type of STEM activities or programs based on innovative teaching tools [7]. Therefore, in this work, STEM workshops have been implemented in the primary education classroom aimed at improving the scientific literacy of students from the earliest stages of schooling.

2. Methodology

The research developed follows a quasi-experimental design with control groups, experimental groups, pre-test and post-test. Specifically, several STEM didactic interventions are carried out in the primary classroom. The general objective of this research is to implement and validate from a didactic point of view the use of STEM workshops in the primary classroom.

The sampling process that has been carried out to select students has been a non-probabilistic sampling of convenience due to the ease of access to different schools. Specifically, 234 4th and 5th grade primary school students (9-11 years old) belonging to five schools participated, in each of which

a different STEM workshop was developed. The students in each centre were divided into two homogeneous groups, one control group and the other experimental. As scientific content, some concepts that are studied in the primary education sciences (Density, Pressure, Physical and Chemical Changes, Light and Matter and Forces) were selected.
Two measuring instruments were developed in relation to the chosen themes. One as a pre-test to evaluate the initial level of knowledge of the participating sample and another as a post-test to check whether the learning of the students improved after the explanation of the contents by means of two didactic methodologies. A traditional methodology based on the use of the textbook and worksheets with the control groups was carried out as opposed to a practical methodology based on the implementation of a STEM workshop with the experimental groups. All the groups had the same time to learn the selected STEM contents.
The research was structured in several phases. In the first phase the students had to answer the pre-test questions in order to detect the previous ideas and the initial knowledge of the groups. In this way, a common starting point is established for the control and experimental groups. The second phase took place several days later with the implementation of the traditional didactic intervention for the control groups and the practical intervention for the experimental groups. Finally, in the third phase carried out several days after the intervention, the students carried out the post-test to evaluate the degree of acquisition of the contents worked in the classroom. In this way, it was possible to compare the didactic validity of the intervention carried out in the experimental groups (EG) with the intervention proposed in the control groups (CG).

3. Results

The mean scores achieved by the students in the pre-test revealed little initial knowledge about the topics selected in the different schools. Specifically, it was decided to choose topics of content that had not been previously studied by the students of the participating groups, in order to establish a homogeneous starting point. Table 1 shows the average grades obtained by the different groups in the pre-test. It can be observed that the students of the experimental and control groups obtained low grades in the initial questionnaire, which was to be expected as these were topics that had not yet been explained.

	Pre-test	
	C.G.	**E.G.**
Centro 1: Density	1.71 (n = 21)	1.60 (n = 21)
Centro 2: Pressure	2.23 (n = 21)	1.90 (n = 21)
Centro 3: Physics and chemical changes	3.71 (n = 28)	3.40 (n = 27)
Centro 4: Light	1.57 (n = 21)	1.80 (n = 23)
Centro 5: Matter and forces	3.56 (n = 25)	2.50 (n = 26)

Table 1. Average scores of the control and experimental groups in the pre-test

Table 2 shows the results obtained by the control and experimental groups in the post-test carried out after the didactic interventions. As can be seen in table 2, there has been a positive evolution at cognitive level in the participating sample after the development of the different didactic interventions. The results confirm that the students of both groups improve their level of knowledge after the didactic intervention. The average scores achieved exceed the passing mark in all groups and schools. However, the students of the experimental groups that followed a methodology based on STEM experiences obtained a higher score than their respective control groups in all the schools.

	Post-test	
	CG	**EG**
Centro 1: Density	5.90	7.23
Centro 2: Pressure	5.43	6.67
Centro 3: Physics and chemical changes	5.47	7.03
Centro 4: Light	5.38	7.15
Centro 5: Matter and forces	5.44	7.15

Table 2. Mean scores obtained by the control and experimental groups in the post-test

Figure 1 shows a comparison of results between the pre-test and the post-test in the different groups and themes.

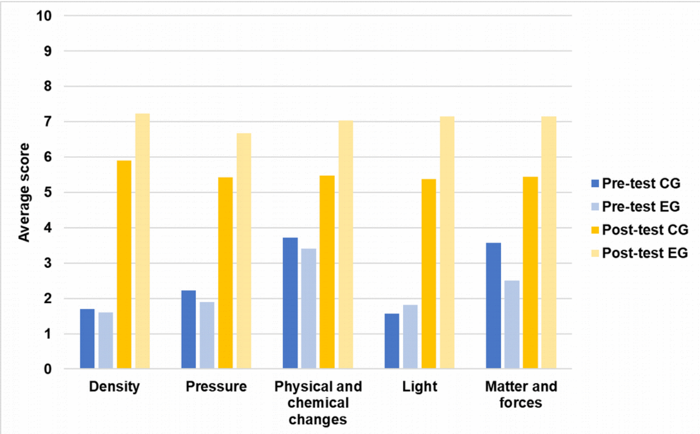

Figure 1. Comparison of the average grades obtained in the pre-test versus the post test

As can be seen in figure 1, STEM workshops produce great benefits when it comes to learning science and technology concepts. The experimental groups have improved their post-test score compared to the pre-test, but they have also achieved better grades than the students in the control group. However, in order to know if there are statistically significant differences in the post-tests of each pair of groups and to be able to validate the effectiveness of the STEM workshops, a Student's t-test was carried out for independent samples. The results obtained are shown in table 3 below.

POST-TEST	t	df	*Sig. (two-tailed)*	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
DENSITY	-2.586	40	0.013	-1.333	0.515	-2.375	-0.291
PRESSURE	-2.087	40	0.043	-1.238	0.593	-2.437	-0.039
CHANGES	-3.428	53	0.001	-1.560	0.455	-2.474	-0.647
LIGHT	-3.940	42	0.000	-1.771	0.449	-2.678	-0.864
MATTER AND FORCES	5.756	49	0.000	2.083	0.361	1.356	2.810

Table 3. Student T-test (post-test)

Table 3 indicates that there are statistically significant differences (Sig. < 0.05) between the means of the control groups and the experimental groups in all the selected subjects, favouring this qualification to the students who participated in the STEM workshops.

4. Conclusion

As a result of the analysis and interpretation of the results presented in the previous section, it is concluded that, in the STEM areas, theory and practice must complement each other in order to achieve significant student learning [8]. In addition, methodologies based on hands-on workshops that integrate scientific-technological areas are more popular with students because they place them in the real context of what they have to learn and provide learning that lasts over time.
In this sense, it would be convenient to include STEM workshops in the didactic programs, especially in the first years of education with younger students, that include activities and practical experiences to introduce the students in these areas of knowledge and contribute to improve their practical and cognitive capacity [9]. Finally, we agree with other authors [10] in considering that the relationship of scientific concepts with the experiment is difficult for the students, that is, the application of the theory to a specific context is complicated, so that the scaffolding provided by the teachers is a key factor for the resolution of this type of activities.

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