Application of Arduino UNO Technology in the Creation of Interactive Educational Robots as a Teaching Resource for Secondary Level Teachers

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Abstract. The objective was to evaluate secondary education teachers from educational schools in the use of the stages of robotics in the creation of interactive educational robots with Arduino. The methodology was quantitative exploratory, pre-experimental design and applied research, involving 41 teachers, evaluating through rubrics in pre and post-test, measuring learning competencies of the stages of robotics. The pre-test, with (7) stages in LEGO WEDO, obtained an average of 12.59, determining that the teacher develops basic knowledge of design and construction in a limited way; The post test with Arduino proposing (5) stages, obtained an average of 15.78, awakening creativity and innovation, was validated with a non-parametric test. It was concluded by accepting a teaching methodology with Arduino with the effectiveness of the use of robotics, improving teaching performance in teaching the stages of educational robotics.

Keywords: Robots, educational robotics, stages of robotics, Arduino.

1 Introduction

Teaching practice in teaching the construction of educational interactive robots today is essential in the training of students, because it allows them to demonstrate innovation, creativity and technological skills. This is indicated by [1] who considers educational robotics as an interdisciplinary learning system that uses robots as a driving element to enhance the development of skills and competencies in students. Along the same lines [2] points out that robotics in education seeks to enhance the ability of students to solve problems in their environment, implement new technologies in an easy and interesting way and focus on learning projects focused on practice. However, as pointed out by [3], the problem of educational robotics is still evident as it is not integrated as a technological learning tool and also a lack of quantitative evaluations that do not allow achieving objectives integrated into training programs.

In [4] they consider that the way teachers teach educational robotics is not the most appropriate, because the aim is for students to acquire knowledge through repetition, however in this activity motivation is left aside, achieving that students are interested in their own learning.

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Although [5] indicates that the majority of teachers, despite the low remuneration they receive, care about training, mastering the basic aspect of technologies and information, which indicates that they want to improve their performance; On the other hand, in educational institutions the development of educational innovation projects is observed, many of which do not respond to the interest and needs of students and do not solve problems of our society, which is why teachers need not only to know basic aspects of technology, but rather preparation, training and guidance in the approach of these projects applying science and technology.

In [6] we find that educational robotics in basic education school curricula encourages technological knowledge and allows the quality of education to increase. The effort made in countries such as Germany, England, Italy, Spain, Canada and the United States of America to integrate educational robotics into their curricula is notable.

As indicated in [7], a proposal was made to incorporate educational robotics for basic and secondary education, supporting the General Guidelines for Education in Technology of Colombia of the Ministry of National Education, managing to design a curricular model that is structured in levels. of complexity, relevant to the principles of meaningful and integrative education.

In Peru, on the PeruEduca platform [8] as a digital system for learning, it is the educational portal that manages the learning of educational robotics, through a methodology called "stages of educational robotics", which includes (7) stages. for robotic prototyping. Educational institutions have Pedagogical Innovation Classrooms where teachers, through this teaching methodology, guide the process of construction of robots by students, however, teachers are not very familiar with the use of technologies, these Classrooms do not have sufficient equipment, such as robotics kits, which are useful for technological learning. The Ministry of Education of Peru distributes to educational institutions the LEGO WEDO robotics kit to apply the stages of robotics in technological laboratories, in limited quantities that often do not cover the teaching need for all students.

According to [9] it is important to consider taking advantage of technologies in the classrooms and enhance student learning, as is the case of the use of the Arduino board, which allows robots to be built in an easier and more integrative way, where feed educational teaching and learning experiences from practices based on innovation projects.

This research allowed us to analyze the teaching of the stages of robotics in technology teachers in secondary schools, with the objective of evaluating the teacher's performance in the use of robots as a teaching resource with Arduino technology.

2 State of the art

According to [10], he carried out the design and systematization of a pedagogical proposal in the field of study of Technology Education, for this he used Educational Robotics as a didactic and technological tool to strengthen creativity skills in a group of 15 students, using a robotic kit. , also an App Inventor online tool for software in mobile robot design, programming in visual language and code language. The students built a circuit using the Arduino Uno board where they controlled a direct current motor (DC motor) with an infrared. It was possible to prove that the students began to have creative ideas and solve problems with technology in a hypothetical way, where they verified and evaluated the assembly, program and operation of the circuit, involving the stages of the design process: build, test, evaluate the prototype, redesign and/or finish. This research concluded in the use of educational robotics, where it was evident that the design of the mobile Robot became a didactic and technological tool for students, learning through design a methodology for solving weakly structured technological problems, promoting value of teamwork.

As [11] says, they developed research that shows a new way of teaching programming to high school students by building projects with the S4A platforms of Scratch oriented to Arduino. The methodology he proposed was in (5) stages (analysis, design, implementation, resolution of exercises and verification of learning) developed in an algorithmic sequential manner, fulfilling

the objective: to educate in the basic programming of secondary schools, observing that the student acquires knowledge of electronics to master the Arduino platform. Programming in Arduino allowed the student to create programs that interact with the environment that surrounds them through sensors and actuators and their own robotic prototypes.

As noted by [12], where he carried out research using Arduino technology as a useful tool in the field of robotics to control mechatronic systems, based on 36 students from the robotics workshop, providing his students with learning by competence and capabilities. programming, use of sensors and electronic circuits. This work aimed to follow Arduino technology to study classrooms to implement industrial robotic systems, managing to determine the range of "good" relationships between Arduino technology, learning and construction; in turn, managing to determine and scale the current "moderate" relationship between Arduino technology, group interaction and significantly with the cognitive level by competency of the introductory robotics course.

From the point of view of [13] they developed a research to know the didactic learning experiences with Arduino and robotics with a methodology based on robotic projects in secondary classrooms, where students not only need to know, but also need to acquire various competencies. The idea began to present the design and development of collaborative projects with robotics with Arduino technology as its central core in technological subjects, motivating students in the use of electronic circuits and programming, showing skills integrated with technology at a level of complexity.

The Ministry of Education of Peru [8] mentions that educational robotics with Lego Wedo is an effective resource for disciplinary work that improves student learning, developing their skills and abilities for socialization, creativity, leadership and collaborative work; which, once learned, will allow them to propose alternative solutions to the problems that arise in their immediate context. Apply (7) stages of educational robotics:

1. **Problematization**: You set a challenge, investigate and explore your environment to propose a problem you want to solve.
2. **Design**: Design a model of possible solutions that can be implemented through the robotics kit.
3. **Construction**: Based on the design, build the model with the necessary parts of the prototype.
4. **Programming**: Through software, program the movements and behaviors of the prototype.
5. **Test**: Based on the design and programming, apply the necessary tests of prototype movements.
6. **Documentation**: Compile evidence that proves the functionality of the design.
7. **Presentation**: The team of participants supports the prototype created as an alternative solution to the problem.

3 Methodology

Applied, quasi-experimental and quantitative research was used because the improvement of performance in secondary level teachers in teaching robotics was experienced and analyzed, through the use of the observation technique and an evaluation rubric with numerical scales. from 10 to 20 to give a value to the teacher's efforts in which it conforms to the following levels of knowledge: "Excellent" (20 points) correct compliance; "Good", (15 points) limited compliance; "Requires support" (10 points) compliance not correct and requires support; According to its scope, it is an exploratory research, because it was identified from an innovative perspective how the stages of robotics are taught.

With a pre-experimental design and a group applied to education teachers, whose notation was pre-test and post-test. (Figure 1)

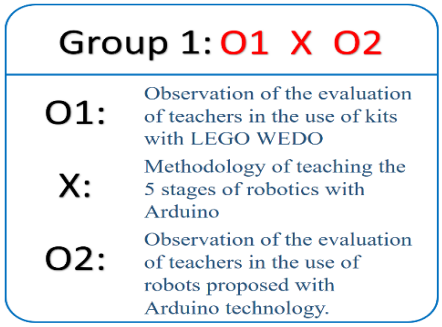

Figure 1: Experiment design

The population was made up of technology teachers from public secondary educational institutions, using a non-probabilistic sample with a number of 41 teachers.

Evaluation techniques were used through observation rubrics to measure the level of performance of the teaching of the stages of robotics in teachers of robotics educational technology areas. The non-parametric Mann-Whitney test was applied to identify the most significant teaching methodology in teachers.

4 Results

4.1 Evaluation and result of the pre-test with LEGO WEDO

Learning sessions were developed for teachers in robotics with the use of the LEGO WEDO Kit, applying a learning pre-test and rubric to evaluate through observation and diagnose the current teaching process of the (7) stages of robotics: (1) problematization, (2) execution, (3) construction, (4) programming, (5) testing, (6) documentation, (7) presentation.

In the evaluation observation of the pre-test, it was found that the teachers in the use of the (7) stages of educational robotics considered by the PERÚEDUCA portal, demonstrated a high value in the knowledge "requires support" in phase 4 (programming) for the 41 teachers in the sample, this indicates that they have a deficiency and low knowledge of the technological tools applied in robotics teaching, since they do not appropriately use programming: robotic control algorithms (Table 1).

Table 1
Results with n=41, pre-test teachers with LEGO WEDO.

Knowledge	Stages of robotics applied with LEGO WEDO						
	1	2	3	4	5	6	7
Excellent	4	4	4	0	4	4	4
Good	24	16	17	0	18	9	11
Requires support	13	21	20	41	19	28	26

4.2 Outline and procedure of the teaching methodology proposal

Seeing the difficulties in building and programming robots in the area of robotics for teachers, a new teaching methodology was proposed to improve the stages of robotics, developing interactive robotic projects with Arduino and thus integrating areas that complement the education of their students. students such as science, technology, engineering and mathematics. For better development and creation of robotic prototypes, the teacher will

apply (5) stages of robotics with Arduino and thus obtain correct technological knowledge (Figure 2). We have the following:

1. **Problem analysis**: Explore your environment and propose the need to solve a problem.
2. **Execution**: Develop the following: the design, using the imagination to create something new and give rise to the design or model of the robot; construction proposes building a solution to the problem based on the necessary electronic parts; Programming is based on the use of logical software programming algorithm to program the movements and behaviors of the robot.
3. **Testing**: Verify and verify the built robot model by developing functional tests and identifying errors.
4. **Documentation**: Once the operation has been tested, document the work carried out.
5. **Presentation**: Share the work by disseminating the knowledge acquired about the operation of the robot prototype.

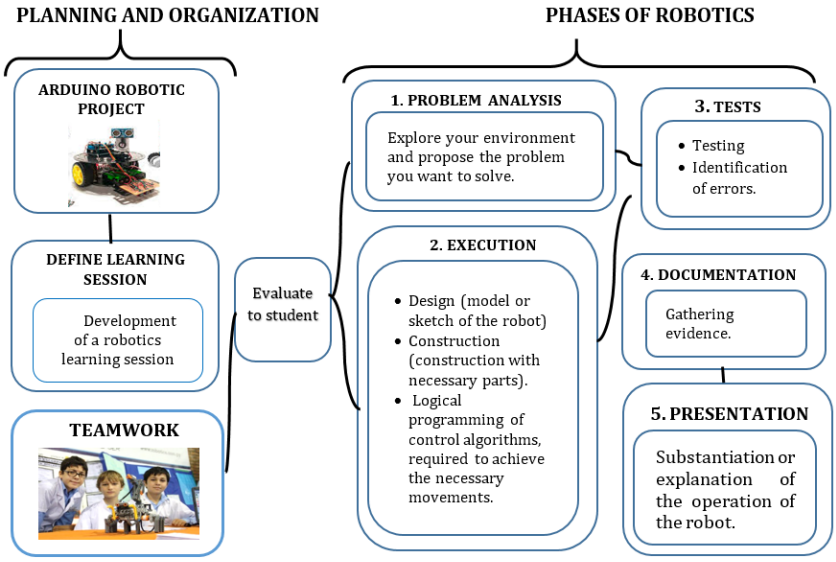

Figure 2: Proposed scheme of the 5 stages of robotics with Arduino.

4.3 Evaluation and result of the post test with Arduino

Learning sessions were developed for teachers in robotics with Arduino technology, applying a learning post test using the observation rubric instrument, to diagnose the learning process of the (5) stages of the proposed robotics: (1) analysis of the problem, (2) execution, (3) testing, (4) documentation and (5) presentation.

In the results of the evaluation post test applying the (5) stages of robotics in teachers, proposed with Arduino technology, the result was that teachers demonstrated a high value in "Good" knowledge in stage 2 of execution, which allowed them to strengthen the teaching of the stages of educational robotics that they will apply to their students, showing appropriate management in design, construction and programming language (algorithms) for the best control of their robotic prototypes (Table 2).

Table 2
Results n=41 teachers, post test with Arduino technology.

Knowledges	Stages of robotics applied with Arduino				
	1	2	3	4	5
Excellent	11	4	7	4	21
Good	30	37	29	32	15
Requires support	0	0	5	5	5

4.4 Analysis of the pre-test and post-test

Analysis with non-parametric tests. When determining that the data (grades by teachers) did not follow a normal distribution, non-parametric tests were used under the following hypotheses: the results are different, but not significantly (H0) and the results are different, but significantly (H1).

Applying the Mann-Whitney test, as seen in Table 3, a value of p=0.000 is obtained, being less than the level of significance (∞=0.05) for which the alternative hypothesis is accepted: the results are different but significant, it means that the robotics teaching methodologies with LEGO WEDO and with Arduino are significant, however, it must be identified which of them is more significant.

To find out which of the methodologies gives the best significance, the SPSS descriptive statistics were used, see Table 4, finding that, in the analysis of the means of the values, the post test has a value of 15.78, being greater than of the pre-test, for which we conclude that the teaching methodology of the stages of robotics with Arduino were significant for the teachers.

Table 3
Mann-Whitney test results.

	Pre test – Post test
Mann-Whitney U	230,500
Wilcoxon W	1091,500
Z	-5,703
Sig. Asymptotic(bilateral)	,000
Grouping variable de agrupación: Groups	

Table 4
Descriptive statistics.

	N	Min	Max	Half	Dev. Standard
Pre test	41	10	19	12,59	2,692
Post test	41	12	20	15,78	2,080
Valid N (per list)	41				

4.5 Proposed robotic prototypes

The construction of various robotic prototypes programmed with Arduino technology was developed with the teachers, such as: Traffic light, which works intermittently, emitting red, green and yellow light (Figure 3); Cart with communication via Bluetooth, controlled with an Android App that connects and links to the circuit and thus manages the movements of the cart (Figure 4); Robot with head and arm movements with servo motors, controlled with a potentiometer. (Figure 5).

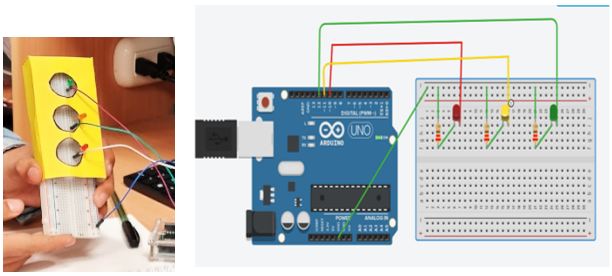

Figure 3: Traffic light robot.

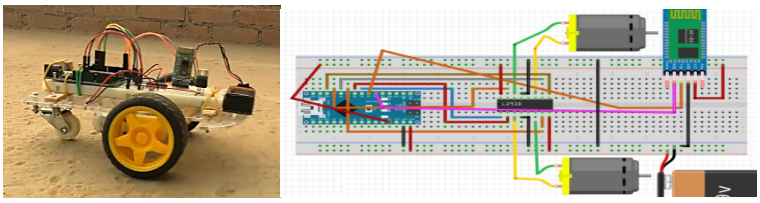

Figure 4: Bluetooth Robot Cart.

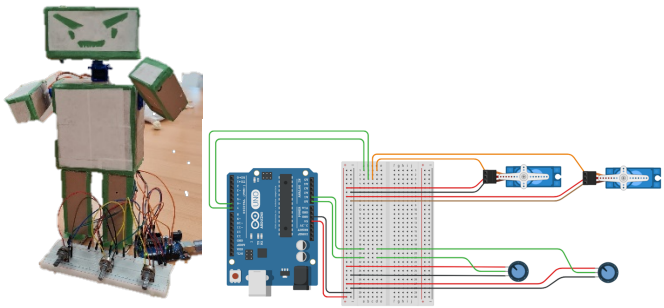

Figure 5: Robot with servo motor movements.

5 Discussion

The results show that after applying the development of educational robots with Arduino technology, an improvement was demonstrated as a robotics teaching resource by teachers, unlike the use of LEGO WEDO where the deficiency in the knowledge of programming and construction.

In this research, the teachers used robotics as part of a didactic and technological tool to improve their teaching with their students in the application with electronic components with Arduino, contributing robots, where they tested and evaluated the physical operation of digital circuits. Similar reports [10] in their results, where a mobile Robot prototype was designed that became a technology teaching tool for students.

The teacher was oriented and was able to use programming with Arduino for the operation of the movements of the educational interactive robots, gradually working on increasing the level of intelligence of his created robot, developing design, construction and assembly principles in its products, also benefiting students' learning of technology in education. Similarly, in [13] digital skills were formed by mastering a technological language through Arduino.

6 Conclusions

It was possible to develop a methodology for teaching interactive educational robots using electronic kits with Arduino technology, where the teacher applied the proposal of the (5) stages of robotics such as "problem analysis, execution, testing, documentation and presentation"; relying on evaluation rubrics.

With the application of the methodological proposal, it is concluded that the teachers demonstrated good interest and acceptance in what was studied through robotic prototypes with innovative electronics with easy-to-program codes, improving their teaching practice and thus strengthening the work stages of robotics. thus achieving comprehensive objectives in training programs through interdisciplinary learning in its students.

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