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Research Article

Mechatronics for Teaching Mathematics

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Abstract

At present, the teaching of mathematics goes through a wide range of modern technologies ICTs in education refer to the set of hardware and software technologies that contribute to the processing of educational information. Due to the great technologic Mechatronics is a field that combines mechanical, electronic, and computer engineering to design and develop advanced systems that can interact with the physical world. When it comes to teaching mathematics, mechatronics can be a valuable tool to help students better understand mathematical concepts and principles. The result of this literature review allows us to see that in Arduino and Raspberry pi for Teaching Mathematics there are few research papers, so there is a great opportunity in this topic, in contrast to the topics Robotics in Mathematics Teaching and ICTS in Math Education there is much more information and amount of research.

Keywords: Mathematics Education, Arduino, Mechatronics Education, Robotics Education

Introduction

At present, the teaching of mathematics goes through a wide range of modern technologies (ICTs) in education refer to the set of hardware and software technologies that contribute to the processing of educational information. Due to the great technologic Mechatronics is a field that combines mechanical, electronic, and computer engineering to design and develop advanced systems that can interact with the physical world. When it comes to teaching mathematics, mechatronics can be a valuable tool to help students better understand mathematical concepts and principles. One way that mechatronics can be integrated into mathematics teaching is by using interactive software and simulations. Mechatronics tools help to visualize and manipulate mathematical equations, formulas, and data. By the other hand mechatronics can be used in mathematics teaching is by incorporating robotic systems. Students can learn to program and control robots to perform mathematical tasks such as solving equations or calculating data and develop problem-solving skills, logical and analytical thinking, and mathematical reasoning Numerical mathematics, as an applied discipline, should be taught on real world examples. By using inexpensive Arduino hardware, we can create simple experiments that are easily reproduced by students. Furthermore, the experiments generate tangible data which can be processed numerically.

There are some authors who are conducting research to take advantage of mechatronics in the teaching of mathematics, this being the objective of this work; highlight the importance of applying mechatronics to the teaching of mathematics through a semi-systematic review of this topic. Likewise, it is necessary to understand that not only the software is important for the application in teaching, but this work also emphasizes that the hardware is also necessary as didactic material to improve the teaching-learning process of mathematics.

Materials and Methods

In mathematics, systematic reviews are common this is demonstrated by; García, [13], Jou, [18], Castro [4], Zabala-Vargas [40], Plaza [33], Ojeda. [31], Salazar [35], Méndez [25], Kanobel [19], however, in this work, a semi-systematic review of the literature was carried out, that is, a mixture of narrative review and systematic review whose definitions are exemplified by Reyna [34], and Moreno [27], since some steps of the systematic review and others were omitted because the main objective is to highlight the importance of mechatronics in the teaching of mathematics, the steps that were followed from the systematic review were; define the research questions, review the search for evidence, extract the data and present the results, the omitted steps were; specify the inclu-

sion and exclusion criteria of the results and evaluate the quality of the studies. The search was carried out in academic Google, and the questions were Arduino and Raspberry pi for Teaching Mathematics, ICT´S in Math Education and Robotics in Mathematics teaching.

Results and Discussion

Mechatronics is a valuable tool in mathematics teaching by providing students with interactive and engaging ways to learn mathematical concepts and principles , so it is necessary to take advantage of them and design new strategies that integrate them for the good of the teaching of mathematics, this work aims to clarify this situation, since only tic's and robotics are talked about in the education of mathematics but you must take advantage of all the knowledge of mechatronics. There is a difference between mechatronics and robotics, mechatronics seeks to create all kinds of machines to complement it with human work, while robotics seeks to replace, in the long term, humans and their tasks so that robots are the ones to do tasks and activities. Robotics is the branch of Mechatronics Engineering that deals with the design, construction, operation, manufacture and application of robots. Connecting theory and practice in teaching is sometimes difficult as it requires expensive or delicate equipment, thus limiting the teacher to giving demonstrations in which students are passive participants .In the next figure show the relationship between Teaching of Mathematics Mechatronics and the other disciplines , being so that the branches of mechatronics for the teaching of mathematics would be the following ;ICT´s Teaching of Mathematics, and Teaching of Mathematics Robotics, and the and the disciplines that contribute to mechatronics for the teaching of mathematics are; Mechatronics, Informatics, Electronics, Simulation Software. In the figure 1 shows the afore mentioned,

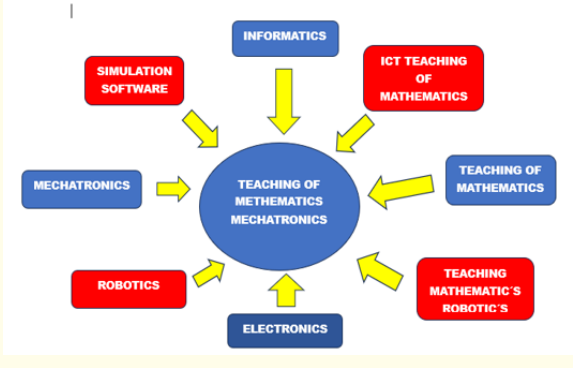

Figure 1: Diagram with the sciences which cooperate to teaching of Mathematics Mechatronics and your Branches.

Arduino and raspberry pi for teaching mathematics

Arduino and Raspberry Pi can be used as educational tools for teaching mathematics. Arduino is a microcontroller board used for building electronics projects, while Raspberry Pi is a single-board computer. Both devices require some level of programming knowledge, which can be a hurdle for students who are new to the field. However, with the right approach and guidance, both devices can help students better understand mathematical concepts. For instance, Arduino is used to teach concepts like algebra and trigonometry through coding projects that involve controlled movements and sensor measurements. Raspberry Pi, on the other hand, can be used for data analysis, visualization, and modeling using programming languages like Python. Overall, incorporating Arduino and Raspberry Pi into math lessons can make for engaging and interactive learning experiences. However, it's important to consider the level of technical knowledge required and provide necessary guidance to ensure students can fully benefit from these tools.

Countless authors to name a few uses Arduino and raspberry Phi to teach robotics and other educational subjects such as programming and electronics, Çoban, A., & Erol, M. [3]. Sari, U. [36]. García-Tudela, P.A. & Marín-Marín, J.A. [12], chemistry Papadimitropoulos, N., Dalacosta, K., & Pavlatou, E. A. [32] but there is limited work on its application to the teaching of mathematics, so there is broad opportunity to research and carry out work in this field.

Author	Description	Year
[37]	Describes an extremely inexpensive, straightforward and surprisingly powerful platform for implementation of real-time control algorithms. The platform consists of an Arduino board and a Raspberry Pi running the REX Control System. The Arduino board is used for interaction with the physical world via its inputs and outputs.	2013
[39]	Presents an educational tool for teaching the numerical methods of bisection and secant through its hardware implementation with a card based on Arduino Due. It is an accessible practice for the university level in which students who are not familiar with programming languages can simultaneously learn numerical methods and the Arduino language given its accessibility and simplicity.	2021
[28]	Propose the incorporation of Arduino technology within the Primary Education classrooms as a tool for teaching mathematics. More specifically, an easy-to-program system has been implemented for teachers that allows performing arithmetic operations of positive integers and representing their results visually	2019

[26]	Development of new tangible game tools for learning basic mathematic concepts. The prototypes can be easily implemented by exploiting new open-source electronic hardware technologies, such as Arduino and related sensors and actuators, combing simplicity, wide diffusion and low cost.	2016
[16]	Present several exercises in numerical mathematics which are based on experiments in electrical engineering with Arduino, and show how to turn them into motivational examples	2019

Table 1: Arduino and Raspberry pi for Teaching Mathematics.

ICTS IN Math education

Although the fact that having technologies in the classroom, by itself, does not cause educational changes has been validated and affirmed, the presence of these means is necessary, Andrade [2]. The study carried out by Echegaray [9] reveals that the more technology education centers have, the greater their use, as well as a greater change in the didactic method, is evident. Integrating ICT (Information and Communication Technology) in mathematics education can have several benefits for both teachers and students; Interactive learning, Collaborative learning, Access to resources, Differentiated instruction. Some examples of ICT tools that can be used in mathematics education are: Graphing calculators and digital math software, educational apps, Online math games and quizzes.

Autor	Descripción	Year
[24]	Demonstrates the importance of these ICT tools in promoting mathematics teaching and learning from elementary school to the university level. Incorporating the ICT tools mentioned above for teaching and learning mathematics has positively impacted students' achievement in mathematics.	2022
[20]	The use of ICT in teaching mathematics can make the teaching process more effective as well as enhance the students' capabilities in understanding basic concepts. Nevertheless, implementing its use in teaching is not without problems as numerous barriers may arise. The types of barriers have been identified in the study. A proposed e-portal to overcome some of these barriers was introduced as part of the on-going research project	2005
[7]	Shows in a study that ICT integration in Mathematics. From literature displayed several problems to utility ICT in mathematics. ICT integration in Mathematics-education has a positive impact on both the teaching and learning process. The study was conducted out to determine the impediments to integration of ICT in mathematics teaching and learning in Teacher-Training colleges & secondary school levels. There are some barriers to integrate ICT in teaching and learning mathematics in various branches of mathematics.	2019
[8]	His case study investigates the impact of the integration of information and communications technology (ICT) in mathematics visualization skills and initial teacher education programs. It reports on the influence GeoGebra dynamic software use has on promoting mathematical learning at secondary school	2017
[30]	In Singapore, research efforts on the use of technology in mathematics education are mainly along one or more of the following strands: (1) how teachers can use technological tools to replace or complement traditional media; (2) how students may benefit from learning with technology; and (3) how technology interacts with other elements of instruction. This chapter provides details of some of these works.	2009
	Analyzing the impact of ICT on mathematics teaching and found so hypothesis is that instrumented techniques are a key in the teacher practices linked to integration.	2003.
[17]	Shows how specific and carefully considered interventions using ICTs can be used to address these teaching and learning concerns. concludes that design of educational technology interventions should be driven by educational needs within the context of a broader teaching and learning strategy which requires buy-in of both educators and learners	2007

Table 2: ICT´S in Mathematics Education.

Robotics in mathematics teaching

Robotics is a valuable tool for teaching mathematics as it allows students to see the practical applications of mathematical concepts in real-life situations, students can use robotics to learn about geometry and spatial reasoning by designing and programming robots to move through specific paths or shapes, in addition also use robotics to explore algebraic and numerical concepts by programming robots to perform calculations or model real-world problems. As well, robotics develop problem-solving and critical thinking skills as they design, build, test, and refine their robots. Overall, incorporating robotics into mathematics education can help make math more engaging and relevant for students.

Author	Description	Year
[41]	Analyzed 20 empirical studies on how to teach and learn mathematical knowledge through robotics. The 20 papers suggest that robotics generally plays an active role in mathematics education; however, there are indeed situations in which no significant improvement was found in students' mathematical learning.	2020.
[14]	Made a small study for further examining ESD issues involved with implementing new technologies and integrating associated activities into the existing mathematics and science curricula to develop an interdisciplinary approach	2008
[10]	Review on educational robotics, its advantages to educational fields, the hardware design and the common programming software used which can be implemented among Malaysian students.	2014
[22]	Presents the results of the pilot study and discusses the pros and cons of using robots in math education.	2019
[15]	Presents the progress of the development of a project where robotics is implemented for the teaching of mathematics in preschool and first grade students, for which three public schools were selected and a series of recreational activities were developed, using low-cost robotic tools.	2019
[3]	Concludes in a study that a simulated environment provides sufficient tools to learn basic notions of robotics, without the need for a physical kit, which can be used for educational purposes. for teaching mathematics.	2022
[1]	Presents the use of the Botnifacio robot as a playful proposal to teach mathematics (arithmetic) at the preschool level in two schools in Guasave Sinaloa during 2018. Through an action research method and a phenomenological construction, it was found that all children maintain the attention in the activity of Botnifacio, even when they do not have the robot in their hands since it is oriented to the playful dimension	2019
[38]	Showed that in general, there is a positive predisposition towards the addition of robots in the learning and teaching of mathematic processes during the first years of school, even though teachers claim there is a struggle to incorporate robots in their lessons due to the high number of students and the reduced space in their classrooms.	2021
[29]	Design, develop and implement educational robotics to improve logical-mathematical skills aimed at preschool and first grade students in public schools, using programmable educational robots.	2020
[23]	Analyze the conditions that are necessary for achieving an effective learning of Mathematics, aided by a robotic platform, results show a impact on the attention and motivation of the students, and they allow for establishing the conditions that need to be met for an effective relationship between the teacher and the technological tool, so that better learning outcomes in Mathematics are more likely to be obtained.	2020
[11]	Present and discuss an activity realized with K-8 level students using robots to learn functions in the mathematics classroom. Research presented is framed by project DROIDE which is a three-year project.	2006
[5]	Developed and implemented an experimental protocol that allows us to improve the levels of focusing on Mexican high school students during a math class using an NAO robot. Three different scenarios were studied.	2019

Table 3

Conclusion

The semi systematics literature review, although not very exhaustive, shows that there is little research on the application of mechatronics in the teaching of mathematics, using the Arduino board and the Raspberry phi microcontroller, so this situation should be considered and take advantage of it, in contrast to the topics Robotics in Mathematics Teaching and ICTS in Math Education there is much more information and amount of research.

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