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Mechatronics in Agriculture and the Teaching of Mathematics

Jaime Cuauhtémoc Negrete[1]

[1] Independent Researcher, Brazil

Correspondence: Jaime Cuauhtémoc Negrete, Independent Researcher, Brazil.

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Abstract

Mechatronics in Agriculture, refers to the integration of mechanical engineering, electronics, control systems, and computer science in designing and creating intelligent systems. In the context of agriculture, mechatronics plays a crucial role in automating various processes to improve productivity, efficiency, and sustainability in farming. By the other hand the teaching of mathematics is an essential component of education, helping students develop critical thinking, problem-solving, and analytical skills. Regarding the teaching of mathematics, integrating mechatronics can provide practical applications for mathematical concepts. Mechatronics systems involve mathematical models, algorithms, and control systems. By incorporating mechatronics projects into math curricula, students can gain hands-on experience applying mathematical concepts to real-world problems. This integration can make mathematics more engaging, relevant, and tangible for students, fostering a deeper understanding and appreciation for the subject. Overall, integrating mechatronics in agriculture not only improves agricultural practices but also offers opportunities to enhance the teaching of mathematics through practical applications. The final recommendation is that mechatronics for the teaching of mathematics should be interrelated with agricultural projects so that students learn in a positive way with contributions to the community, likewise research in this regard should be promoted since it is null in these topics.

Keywords: mechatronics, agriculture, Raspberry pi, mathematics, teaching, ICT’s

1. Introduction

Mechatronics in Agriculture, refers to the integration of mechanical engineering, electronics, control systems, and computer science in designing and creating intelligent systems. In the context of agriculture, mechatronics plays a crucial role in automating various processes to improve productivity, efficiency, and sustainability in farming. It involves the use of sensors, actuators, robotics, drones, and precision farming technologies to optimize tasks such as planting, irrigation, harvesting, and monitoring crop health. Mechatronics in agriculture is focused on enhancing resource utilization, reducing labor costs, and enabling data-driven decision-making for farmers. By the other hand the teaching of mathematics is an essential component of education, helping students develop critical thinking, problem-solving, and analytical skills. Effective mathematics instruction involves introducing students to foundational concepts and gradually building upon them with hands-on activities, real-world applications, and interactive learning experiences. It is important to create a supportive learning environment that encourages student engagement and participation. Additionally, incorporating technology tools and educational software can enhance mathematical learning and provide opportunities for personalized instruction. It is crucial for teachers to adapt their teaching methodologies to meet the individual needs and learning styles of students while making mathematics enjoyable and relatable. The objective of this work is to show the advantage of interrelating mechatronics for the teaching of mathematics with agricultural projects so that students learn in a positive way with contributions to the community.

2. Material and Methods

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 (2021), and Moreno (2018), 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 inclusion 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, mechatronics in agriculture and Arduino agriculture.

3. Results and Discussion

3.1 Mechatronics for Teaching Mathematics

Negrete (2023), it proposes the terminology of educational mechatronics, as it states that mechatronics in addition to having various applications in other areas such as agriculture Negrete (2015, 2016). 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.

3.1.1 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. The following authors have worked on it Sobota (2013), Serrano (2021), Morón (2019), Mollo (2016), Herceg (2019).

3.1.2 ICT'S 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, (2020). The study carried out by Echegaray (2014) 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. This Authors made investigation about this; Maharjan (2022), Keong (2005), Das (2019), Dockendorff (2017), Ng, W. L., (2009) Lagrange (2003) and Jaffer (2007).

3.1.3 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. These authors conducted research related; Zhong (2020), Gerretson (2008), Felicia (2014), Leoste (2019), González (2019), Castro (2022), Alzate (2019), Seckel (2021), Muñoz (2020), Lopez (2020), Fernandes (2006), Caudana (2019).

3.2 Mechatronics in Agriculture

Agricultural mechatronics term created in 2015 by Negrete, need of some sciences as shown in Figure 1 including; the Agromatics which is the application of the principles and techniques of computer science and

computer theories and laws of operation and management of the agriculture intended to serve as operational support in diagnosing problems and in the design and evaluation of alternative solutions. Innovative Agricultural Mechatronics give to support precision agriculture in the small farm holdings of the developing and the underdeveloped countries. It should essentially evolve as a branch of agricultural engineering. Precision agriculture powered by agricultural mechatronics is playing a key role in optimizing agricultural productivity in the developed countries. To prevent food crisis in the years to come, suitable technology to support precision agriculture has to be developed in the developing and the underdeveloped countries.

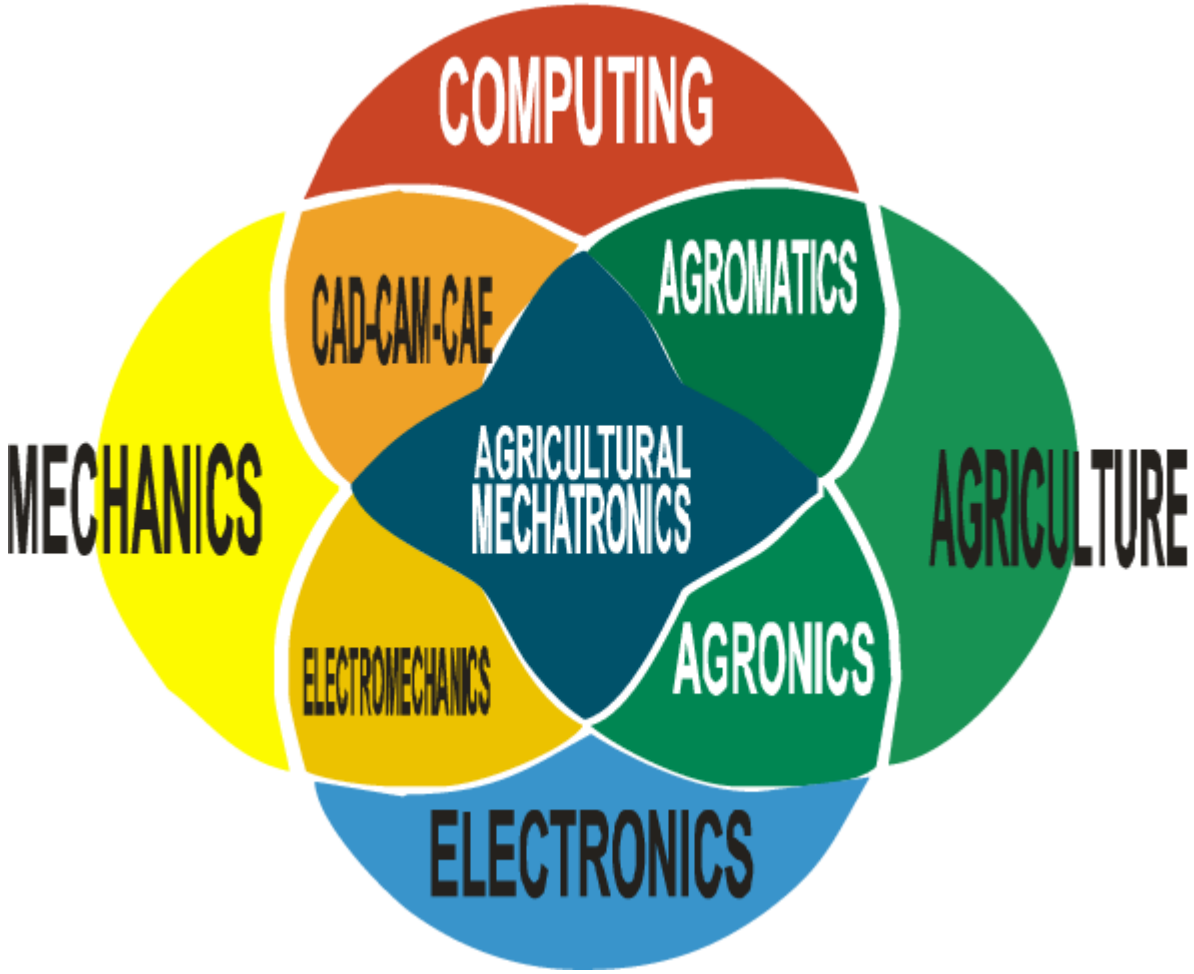

Figure 1. Diagram with the sciences which cooperate to agricultural mechatronics

Source: From Negrete (2015).

In Mexico, agricultural mechatronics has taken a certain boom from the work of Negrete (2015), (2017), (2020) managing to achieve that the UACH has created the career of Agricultural Mechatronic Engineer in 2018, for which the country is a pioneer in this branch of agricultural engineering thanks to this author. Likewise finally Niels (2019) found that agricultural mechatronics modular-course has a positive effect on students' learning and unit course "applications of sensor in agriculture" is popular with students.

4. Discussion

Integrating the teaching of mathematics with mechatronics in agriculture can greatly enhance students' understanding in both subjects. Here's how it can be done:

1). Real-life Applications: Provide students with real-life agricultural scenarios where mechatronics technologies are used. For example, teach them about automated irrigation systems or robotic harvesting machines. Then, encourage students to apply mathematical concepts such as geometry, algebra, and calculus to analyze and improve the efficiency of these systems.

2). Data Analysis: In mechatronics, data collection and analysis play a vital role. Students can use mathematical tools and statistical analysis to interpret the data collected from sensors used in agriculture. They can analyze

trends, make predictions, and optimize systems based on mathematical models.

3). Problem-solving: Combine mathematical problem-solving techniques with mechatronics challenges. Encourage students to design and build mechatronic systems to solve agricultural problems. This process will require them to apply mathematical concepts like trigonometry, kinematics, and optimization to develop effective solutions.

4). Programming: Mechatronics often involves programming microcontrollers or using software tools. Integrate mathematical principles like algorithms, logic, and sequences into programming exercises, enabling students to develop mathematical thinking while working on mechatronic projects.

5). Collaborative Projects: Encourage students to work in teams, where they can apply mathematical concepts to design, build, and program mechatronic agricultural systems. As they work together, they can learn how each subject complements the other and gain a holistic understanding of both mathematics and mechatronics.

By integrating mathematics with mechatronics in agriculture, students can see the practical applications of mathematical concepts, develop problem-solving skills, and gain a deeper understanding of both fields.

5. Conclusions

Integrating mechatronics in agriculture can bring numerous benefits. Mechatronics combines mechanical engineering, electronics, computer science, and control engineering to create smart and automated systems. By integrating mechatronics in agriculture, farmers can automate various tasks such as seeding, plant watering, fertilizer dispensing, crop monitoring, and harvesting. This automation improves efficiency, reduces labor costs, and optimizes resource utilization. Furthermore, mechatronics can enhance precision agriculture techniques. By integrating sensors and actuators into agricultural machinery, farmers can collect real-time data related to soil moisture, temperature, and nutrient levels. This information can be used to make data-driven decisions and apply inputs precisely, leading to optimized crop growth and yield. Regarding the teaching of mathematics, integrating mechatronics can provide practical applications for mathematical concepts. Mechatronics systems involve mathematical models, algorithms, and control systems. By incorporating mechatronics projects into math curricula, students can gain hands-on experience applying mathematical concepts to real-world problems. This integration can make mathematics more engaging, relevant, and tangible for students, fostering a deeper understanding and appreciation for the subject. Overall, integrating mechatronics in agriculture not only improves agricultural practices but also offers opportunities to enhance the teaching of mathematics through practical applications. The final recommendation is that mechatronics for the teaching of mathematics should be interrelated with agricultural projects so that students learn in a positive way with contributions to the community, likewise research in this regard should be promoted since it is null in these topics.

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