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Modelo de Robótica Educativa con el Robot Darwin Mini para Desarrollar Competencias en Estudiantes de Licenciatura

An approach to educational robotics using the Darwin Mini Robot as a tool for undergraduate skill development

Model Robotics Educacional com o Darwin Mini Robot para Desenvolver Competências em Estudantes de Bacharelado

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Resumen

En este trabajo se plantea la utilización de un robot didáctico para fomentar el desarrollo de competencias, que es una vertiente novedosa que se genera en el ámbito académico y de investigación para el fortalecimiento del conocimiento multidisciplinario en estudiantes de nivel Licenciatura. Para esto se planteó y diseñó un conjunto de estrategias que se implementarán con los estudiantes mediante la herramienta tecnológica más adecuada que se tenga disponible, realizando previamente un amplio análisis de los diferentes Robots con fines didácticos que hay en el mercado para poder elegir la opción que mejor se adapte a nuestras necesidades, por lo cual se seleccionó el Robot Darwin Mini de la marca Robotis, que es un robot de forma humanoide que contiene una amplia gama de utilidades y funcionalidades que les permiten a los estudiantes motivar y potenciar el aprendizaje en diferentes ámbitos de la educación, desde la construcción del robot que requiere la intervención de varias disciplinas como mecánica, informática, electrónica, matemáticas, física, etc., hasta su programación y utilización, que implica a su vez otro conjunto de conocimientos. Dichas estrategias permiten identificar las pautas a seguir que se consideran en un modelo de robótica educativa.

Palabras clave: robótica, aprendizaje, educación, multidisciplinario, competencias.

Abstract

This paper examines the use of educational robots for skill development, a new topic in the academic and research communities aimed at enhancing multidisciplinary undergraduate education. A set of strategies was proposed and developed to be implemented in the classroom using the technological tools most suitable for the job. Beforehand, the various educational robots on the market were analyzed extensively to determine the best option for our needs. The ROBOTIS Darwin Mini Robot was selected, which is a humanoid robot with a wide range of uses and features that can enhance and encourage learning in various fields of education, as the robot's assembly requires knowledge of disciplines such as mechanics, computer science, mathematics, physics, etc., and its programming and application in turn require knowledge of other fields. These strategies lay out the guidelines to be followed as part of the educational robotics approach.

Keywords: robotics, learning, education, multidisciplinary, skills.

Resumo

Neste artigo, propomos o uso de um robô didático para promover o desenvolvimento de competências, que é um aspecto inovador gerado na área acadêmica e de pesquisa para fortalecer o conhecimento multidisciplinar em estudantes de graduação. Para esse efeito, um conjunto de estratégias foi desenvolvido e implementado com o Robot Darwin Mini da marca Robotis, que é um robô humanóide que contém uma ampla gama de utilidades e funcionalidades que permitem aos alunos motivar e melhorar a aprendendo em diferentes áreas da educação, por isso foi selecionado para este projeto para explorar suas características, realizando uma extensa análise das diferentes opções oferecidas pelo

mercado para justificar a escolha desta opção, desde a construção do robô que exige a intervenção de várias disciplinas, como mecânica, informática, eletrônica, matemática, física, etc. Até a programação e utilização que, por sua vez, implica outro conjunto de conhecimentos. Essas estratégias permitem identificar as diretrizes a serem seguidas que são consideradas em um modelo de robotização educacional.

Palavras-chave: robótica, aprendizagem, educação, multidisciplinar, competências.

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Introduction

Robots are increasingly popular used as an educational platform. Working with robots is very stimulating for young students, in addition to allowing them to acquire important skills that will help them throughout their school career and even during their daily lives, such as better understanding the scientific approach, acquiring problem-solving skills, encouraging their creativity, develop your teamwork spirit, awaken your interest in research, etc. Educational robotics is a learning method based on the pedagogical current of constructivism that promotes the design and development of own creations.

It has been shown that getting started in robotics helps students prevent school failure. At the higher education level, robots and robotic kits allow the student to work with real hardware to be prepared for the challenges of real physical work.

Robots have been gradually incorporated into society, so the number of service robots already exceeds industrial robots, which was the sector where they were used most frequently according to the Department of Statistics in its Global Robotics Survey (IFR)) in 2008. At the moment they are beginning a process of perfect integration with the daily life of people, both at home and at school. This impact of social robotics is even more important when we talk about children and adolescents, because it is with whom robots can be used to enhance their development and intellectual growth.

For all the above, more attention should be given to how educational robots can better integrate into the lives of young people. With the continuous advances in technology, it is worth understanding the potential of robots as effective complements for learning. Robots can be a fun platform to learn about computers, electronics, mechanical engineering and languages (among many other things). There are studies that show that young children perform better in apprenticeship evaluations, besides showing greater interest, when language learning took place with the help of a robot, compared to the use of audio tapes and books only (Han et al., 2008). Educational robots are a subset of educational technology, in which they are used to facilitate learning and improve the educational performance of students. These provide the student with a form of realization and the ability to add social interaction to the context of learning, therefore they have better learning compared to what they get when learning is based solely on software.

In this work, an analysis is made to propose the use of robots in education at the University Center UAEM Valle de Chalco. The main objective of this research is to provide a general view because there is no complete picture of the field of robots in education in robotic literature.

Description of the Method

Context of the proposed model of RE.

The European Projects Department of the National Institute of Educational Technologies and Teacher Training (INTEF) presents the report "The NMC Horizon Report: 2016 Higher Education Edition", produced jointly by New Media Consortium (NMC) and EDUCAUSE Learning Initiative (ELI)), identifies and describes the six emerging technologies that will have a significant impact on higher education in five years (2016-2020).

A summary of the publication of the Horizon report presented by the Universitat Jaume I of Castellón, Spain indicates the trends, challenges and important technologies that set a key trend on the significant challenges and priority developments that educational technology for higher education should consider (2016) .

In each of these sections of the 2016 Horizon Report, three short or medium and long term adoption or resolution horizons are distinguished. The third adoption horizon presents the important developments in educational technology for higher education, considering long-term projects for four or five years, as the potential uses of robotics. This work is intended to contribute to issues internationally considered but with national relevance, which involve various lines of research and in specific cases, such as Computer Engineering and Management Informatics and Master's and Doctorate programs in Computer Science , in the area of Artificial Intelligence (AI) and Robotics, which include the aforementioned study programs of the University Center UAEM Valle de Chalco.

Also, the technical and pedagogical aspects have to be taken into account, since both are necessary for the professional evolution of the students. Without the incorporation of pedagogical knowledge, evolution in the construction of concepts of Educational Robotics (RE) is not possible, but this evolution is not possible if the professionals who have to participate in it do not possess the appropriate technical knowledge.

Important factors to consider in order to develop robot learning.

With an exhaustive research in the literature we were able to determine the following factors, as the most important to consider when trying to apply learning in a classroom by using robots. These factors are the following: What is studied? When is it studied? and How do you want to study?

Therefore, a model is proposed with a constructivist approach to the design of learning that allows students to build meaningful learning outcomes with educational intentions embodied in the study programs of the learning units in the area of IA and RE, indicated below:

- Learning to KNOW, which leads us to define declarative objectives that include the learning of theories, principles and concepts.
- Learning to LEARN, which leads to the definition of development objectives of skills and competences.

- Learning to DO contains procedural objectives related to learning methods, techniques and procedures.
- Learning to LIVE with others, which supports objectives that allow recognizing, respecting and addressing differences and the search for collaboration.
- Learning to BE, which involves attitudinal objectives such as creativity, values, attitudes and decision-making.

The phases of the proposed model are focused on Educational Robotics and there are five that consider different functions: from defining what is learned, specifying how it should be learned, to a process of authorizing the materials to be used, as well as contextualizing daily and family activities to the student

Phase 1: Definition of the topic of the learning activity

The first criterion that should be very clear is the subject of learning. The two main categories, although quite broad, are robotics and computer education (a general introduction to technology awareness that might be called technical education) and non-technical education (science and language). Technical education is the notion of giving students the knowledge of robots and technology. In most cases this is done with the aim of introducing computer science and programming and familiarizing students with technology (Balch et al., 2008). In (Mubin et al., 2012) a study is presented where Dutch high school students were gradually exposed to technical subjects using robots. A lesson plan usually involves first an initial introduction to the robot's programming (introduction phase) and then students apply their knowledge practically making their robots work (intensive phase) (Chiou, 2004). The introduction phase usually helps when students are not familiar with the use of robots in education. Since students also build the robot in these activities, they are usually quite educational activities. The activity of building your own robot has proven to provide a strong sense of ownership and greater interest in students, since students can take their robots home, interacting with them during free time, etc. The second most used application in the area of robots in education are non-technical subjects (such as sciences), where the use of robots is seen as an intermediate tool to impart some type of education in areas such as mathematics and geometry (Tertl, 2017). In such scenarios, robot movement is typically the main subject on which learning is based. For example, Highfield et al. (2008), in a project executed in Australia students discuss the concept of rotations and transformations based on the movement of the robot. Another example is to analyze the trajectory of a robot's path to interpret angles and geometry. Other examples of non-technical applications of education, using robots, are areas such as kinematics (Mitnik et al., 2008) and the orchestration of music (Han et al., 2009) in Korea. The third most common application in the current literature is the use of robots to teach a second language. For example, English was taught to Japanese children by a robot as shown in Kanda et al., (2004) by researchers at the robotic laboratory ATR, Kyoto and in Han & Kim, (2009) English was taught to the Korean children with another robot. The implications of using robots to teach a second language have been well documented (Chang, 2010) by computer researchers in Taiwan, who claim that children are not as hesitant to talk with robots in a foreign language as they are when they talk to a human instructor. In addition, robots can easily behave in a repetitive manner while students are talking to them, allowing students to practice without the problem of a tired human instructor. In addition, the realization of a robot and its social capacities is discussed here as an important aspect of language teaching. Another critical issue is that language instruction requires an exact recognition of speech and that it is one of the obstacles to recognizing the use of robots for language teaching as shown in (Okita et al., 2009). This is precisely the reason why some researchers use Oz assistant techniques (a human controls the robot behind the scenes) to execute their experiments (Han & Kim, 2009). For some of the aforementioned studies on the use of robots to teach language, difficulties may arise to achieve validation. The studies were carried out for a few weeks and therefore a large component of the language was not learned. The fourth most common application in the field of educational robotics is when robots are used for the cognitive development of students, but this is not discussed in depth, as this application will not be carried out since it is required to apply to students of pre-school age. -School to elementary school and we are focused on using educational robotics at the university level.

Phase 2: Delimit where learning occurs

The second criterion to consider is the location of the learning activity. The use of robots in education is intra-curricular or extra-curricular. Intracurricular activities are those that are part of the school curriculum and are part of the curriculum. Some robot competitions could even be included as part of formal learning, since they take place towards the end of the learning activity and are a form of evaluation-based learning (Almeida et al., 2000). Extracurricular (or extra-curricular) learning takes place after school hours at the same school as workshops under the guidance of instructors, at home under the direction of the parents; or in other designated places, such as public places and events. Extracurricular activities are usually more relaxed, allow deviations and therefore, are easier to configure and organize. There are several examples of the use of curricular educational robotics in formal settings (Balch et al., 2008). One of the main advantages of carrying out informal sessions with educational robots on the formal advances of the curriculum is that they are short-lived and require a minimal design of the curriculum. However, informal sessions are usually short and short, therefore, their final impact can be questioned.

Table 1. Ejemplos de Actividades desempeñadas en los diferentes roles de los Robots Educativos

Roles de los Robots	Como Tutor	Como Acompañante	Como Herramienta
En el aprendizaje de Idiomas	El Robot ayuda a los estudiantes a recordar vocabulario.	Cuando el estudiante pronuncia una palabra correctamente, el Robot le dice "¡Bien hecho!"	El estudiante aprende ciertas frases en un lenguaje que no conoce, jugando algún juego con el Robot.
Para aprendizaje de Ciencias	El Robot adapta ejercicios aritméticos basados en el desempeño del estudiante.	El Robot y el estudiante resuelven ejercicios de ciencias de forma colaborativa.	El Robot habilita sus sensores y actuadores para que el estudiante aprenda acerca de física.
Para aprendizaje de Tecnología	El Robot discute la dificultad de tareas de programación con el estudiante.	El Robot reproduce alegres sonidos de ánimo cuando el estudiante completa satisfactoriamente un programa del Robot.	El estudiante utiliza una interfaz de un Robot educativo para aprender su lenguaje de programación.

Fuente: Elaboración propia.

Phase 3: Different roles that a Robot develops during learning

The robot can assume a series of different functions in the learning process, with different levels of participation in the learning task. The choice depends on the content, the instructor, the type of student and the nature of the learning activity. First, on the one hand, the robot can assume a passive role and be used as a didactic learning tool. This would apply especially to robotics education, where students would be building, creating and programming robots. On the other hand, the robot can assume the role of a partner and have active spontaneous participation (Okita et al., 2009), where the focus was on cooperative learning with the robot, or even being a recipient of attention (Tanaka & Matsuzoe, 2012), where students learn English on the road while teaching a robot. The role of a robot as a mentor has also been discussed in (Goodrich & Schultz, 2007). However, it is clear that before the robot can assume the role of an autonomous mentor, technological advances are necessary in the perceptive abilities of social robots. In summary, we can define three main categories of the role of a robot during the learning activity: tool, partner or tutor (Table 1 shows and explains these three roles and gives some examples). From all this we can deduce that we need to draw a clear map that links the learning activity with the robot's interaction style. For example, for basic learning tasks, a cooperative robot was preferred in comparison with an instruction robot (Okita et al., 2009), but for language learning, a style of tutoring was preferred (Saerbeck, 2010). This decision is also governed by the perception of the students. It has been shown that younger children were content with robots behaving as partners in the learning process while older children thought of robots more as teaching tools. The degree of social behavior of the robot is more or less related to the role played by the robot during the learning activity, the domain of the subject and the age of the students. According to Okita et al. (2009), it was found that the students preferred a behavior and a human-type voice for the robot. Other attributes such as maintaining eye contact have also been discussed in (Johnson et al., 2000) to attract students. For language learning and cognitive development, social interaction is essential, as suggested by Shin & Lee, (2008) (although it may not be essential for technical education). A survey of two robots was conducted with respect to 4 weeks of use at home and school. The two robots were an emotionless humanoid and an animated robotic dog. The conclusion was that the students preferred the robotic dog. Similar results were obtained by Moreno et al., (2001), where it was found that a social agent generated much more interest compared to a less social agent and by Saerbeck et al. (2010), where a more social robot led to higher scores in later evaluations than using a human instructor in teaching. The restriction of the way a robot "looks" physically is more flexible; For example, a humanoid robot could potentially be used to teach any subject. However, previous research has examined the physical attributes of a robotic teacher. According to Ryu et al. (2007), a quantitative analysis of the preferred dimensions of the physical characteristics of humanoid educational robots is presented.

Phase 4: Types of robots used in education

The realization of the robot is also a critical factor in the learning activity. There are numerous robotic kits, ranging from low-cost, single-function kits to humanoid robots that cost thousands of dollars. To explore the various options, we can consider a hypothetical progressive scale of incarnation. At one end of the scale there could be low-cost single-function mechanical kits that are typically used to illustrate only one function, such as following a line or reacting to the sound source. Further down the scale, we have kits that provide the option to educate not only about robotics, but also electronics. These kits are completely programmable and students can also build robots and upload scripts to them. Finally there would be kits that allow greater mechanical freedom and flexibility with the design of the robot like the LEGO Mindstorms. It has been shown that Mindstorm robots teach a wide range of topics ranging from language (Mubin et al., 2012), computer science / programming (Powers et al., 2006), physics (Church et al., 2010) , engineering design (Ringwood et al., 2005) and robotics (Hirst, 2003). In addition, we have robots as fully incarnated agents used in both formal and informal education, such as the humanoid robot NAO (Tanaka & Matsuzoe, 2012), robots incarnated as pets or toy characters. These robots have the ability to participate in social interaction, by virtue of being able to talk and display facial expressions. In most situations, these robots are used to teach non-technical subjects such as language or music, which require the robot to engage in some form of social interaction with the student. Not all robotic kits will be attractive to all types of students.

Table 2. Ejemplos de la relación entre los usos de los Robots y el dominio de la programación que logran adquirir los estudiantes.

Tipos de Robots	Kit Electrónico para Armar un Robot	Robots de tipo humanoide
En el aprendizaje de Idiomas	Kit de Robot LEGO Mindstorms enseña de idiomas a los estudiantes mediante juegos. Bajo nivel de Conocimientos de Programación aprendidos.	El Robot Humanoide Robovie enseña un idioma al estudiante de forma interactiva. Bajo nivel de Conocimientos de Programación aprendidos.
Para aprendizaje de Ciencias	Los estudiantes utilizan el Acelerómetro del Robot Thymio, para entender los efectos de la gravedad. Medio nivel de Conocimientos de Programación aprendidos.	El Robot Humanoide Nao enseña los efectos de la Física pateando una pelota. Medio nivel de Conocimientos de Programación aprendidos.
Para aprendizaje de Tecnología	El estudiante puede armar y programar el Robot Darwin Mini para realizar diversas actividades para aprendizaje de Tecnología. Alto nivel de Conocimientos de Programación aprendidos.	El estudiante universitario tiliza los sistemas de Visión del Robot Humanoide Nao para implementar sistemas de Visión Artificial. Alto nivel de Conocimientos de Programación aprendidos.

Fuente: Elaboración propia.

For example, we can not expect young children to build complex robots or even use them. On the contrary, to attract young children, the robot must have animated features. Therefore, it is suitable for teaching subjects such as mathematics (Highfield et al., 2008) and programming (Stoeckelmayr et al., 2011) to young children. In general, educational robots must be designed to take into account the age and requirements of students or must be adaptable in real time. For example, as shown in Ruvolo et al. (2008), the robotic technology was developed that allowed a robot "Asobo" to adapt its behavior based on the prevailing mood of young children. Ultimately, the choice of which robot to use in the learning activity depends on several factors: cost, domain that is required to obtain the student and their age. We provide some examples of the type of robots used for each type of domain required by the user in Table 2. The level of programming skills acquired by students when using each type of robot is indicated in each cell.

Phase 5: Selection of the robot that allows to implement the best strategies for the development of competences

Once analyzed all the roles and functions provided by the different types of robots that are available today in the market, we can determine that the Robot Mini Robotis Darwin Robot will provide us with the best features that will allow us to implement strategies to promote development of competences of diverse topics that require students to develop the educational programs of the area.

This Robot was chosen over others that exist in the market because it presents characteristics that make it ideal to be able to develop important competences in the undergraduate students, starting with the fact that the Robot comes totally disarmed with tools and instructional to arm itself, which allows input that students work in teams to successfully complete the assembly of the Darwin Mini Robot. Once armed, it is possible to interact with it through a mobile application that allows it to work on Android and iOS operating systems (although for the latter it requires the acquisition of a special module) which makes it very attractive for students to be able to program it. interact with him through any cell phone or tablet that is a tool that they handle on a daily basis, but also makes it ideal to encourage group learning. Figure 1 shows the Robot selected to implement the Strategies for the development of competences in our students.

In addition, a test was developed to evaluate the learning of two groups of 15 students each. The test consists of 90 questions divided into 5 areas, distributed as follows:

- Mathematics (Logic, Geometry and Trigonometry) contributed 30 questions
- Basic Robotics contributed 15 questions.
- Advanced Robotics contributed 15 questions.
- Basic Programming contributed 15 questions.
- Advanced Programming contributed 15 questions.

Figure 1. Robot Darwin MINI de la marca Robotis

Fuente: http://www.robotis.us

This instrument allowed us to evaluate the performance of the two groups of students. In the first, the topics were viewed theoretically in the classroom using slides, to prepare the group to perform the evaluation. The second group saw the subjects through practices with the Robot Darwin Mini which facilitated the learning of most of the subjects, as can be seen in Table 3, which shows the average of the evaluation obtained by each group of students and for each area on a scale of 0 to 100. The results obtained show that the group of students that learned the subjects using the Darwin Mini Robot as a tool, managed to obtain a more solid and acquired knowledge in a more didactic and friendly way, in all areas of knowledge evaluated.

Table 3. Resultados Promedio de Evaluaciones de dos Grupos de Estudiantes

Áreas que se Evaluaron en los Estudiantes	Evaluación promedio en Grupo que No Utilizó el Robot	Evaluación promedio en Grupo que Sí Utilizó el Robot	Índice de Mejora Alcanzado
Matemáticas (Geometría y Trigonometría)	75.2	92.1	16.9
Robótica Básica	81.7	92.3	10.6
Robótica Avanzada	72.4	91.6	19.2
Programación Básica	80.3	91.2	10.9
Programación Avanzada	69.2	92.4	23.2

Fuente: Elaboración propia.

The Table also shows the improvement index obtained in each area, by the group of students who used the Robot Darwin Mini, where you can see how in the worst case there was an improvement of 10.6 points for the area of Robotics Basic and up to 23.2 points for the Advanced Programming area.

Final comments

In the results it is clearly seen that when the proposed Darwin Mini Robot was used as a learning tool in all the areas evaluated, the students' learning was improved, but also collaborative learning and teamwork were promoted, and they were also possible. develop other competences when carrying out their group learning, due to the interaction they must perform among themselves and with the robot, in order to achieve the practices in an appropriate way.

Summary of Results

In this paper we first analyzed the different roles that robots can play in the field of education, in order to determine what type of robot that can be found in the market, better covers the necessary characteristics to promote the development of of Competencies in our students. The results obtained are quite encouraging, and we can expect that by expanding the implementation to more numerous groups, we can also obtain better performance in the evaluation of the different skills that we seek to develop in our students.

Conclusions

The results obtained demonstrate the effectiveness of the use of the Darwin Mini Robot to implement competency development strategies, which is why its choice to use it is justified. This demonstrates that the previous analysis that was made of the different roles played by the Robots in Education was successful. The evaluation of the students improved up to 21.2 points on average in the advanced topics of the subjects (Robotics and Programming), and in 16.9 points for the areas of Mathematics, which are the ones that are usually the most complicated to learn for the students. It is expected, therefore, that the learning of the undergraduate students can be improved by implementing this tool in some learning units of the educational programs.

Recommendations

Researchers interested in continuing our research could adopt the implementation of the Darwin Mini Robot, since in addition to all the benefits already discussed is a robot at an affordable price compared to others that we can find in the market (such as the NAO Robot) of Robotis) and we consider the functionalities and advantages that it offers us for its use in the implementation of collaborative learning strategies. The purpose is not to advertise this robot, but our recommendation is based on the results of this investigation.

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Análisis Formal	**Cristina y José Luis, «igual»**
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