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Socially Assistive Robotics: State-of-the-Art Scenarios in Mexico

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Abstract

In this chapter, we describe the experience about the use of a humanoid robotic platform, in scenarios such as education and health in Mexico. The results obtained are commented on through the perspective of cultural, technological, and social aspects in the frameworks of education (from elementary to high school) and training of health professionals. The opening towards humanoid robotic systems in elementary school children, as well as health professionals, is not far from the acceptance due not only for the technological advancement but also for different social aspects. These two considerations influenced the results obtained and experiences achieved. At the same time, this chapter shows how humanoid robotics has functioned as a tool for final projects of undergraduate students.

Keywords: social robotics, assistive education, higher education, educational innovation

1. Introduction

The implementation of biped and humanoid robots has increased during the last decade around the world. Depending on its characteristics, these robots can be implemented in different areas and domains, such as manufacture, agriculture, health, and education, among others. For the rest of this chapter, every reference will treat the last two applications mentioned, particularly rehabilitation, patient assistance, and elementary children's education.

Depending on the functionality of the robot, it can be classified into three different types [1], as seen in **Figure 1**. The first type of robot is called an assistance robot (AR). Its functionality is based only on giving physiological assistance to a patient that presents a physical disability or is recovering from a surgical operation. This type of robots regularly presents a basic structure, since they have one single task and the work environment does not vary too often.

On the other hand, as the name suggests, socially interactive robots (SIR) have the task of interacting with the end user with the sole purpose of generating a certain level of communication and entertainment to him. Generally, these platforms have a more complex design, since they need to detect and use human behavior patterns to achieve an efficient interaction.

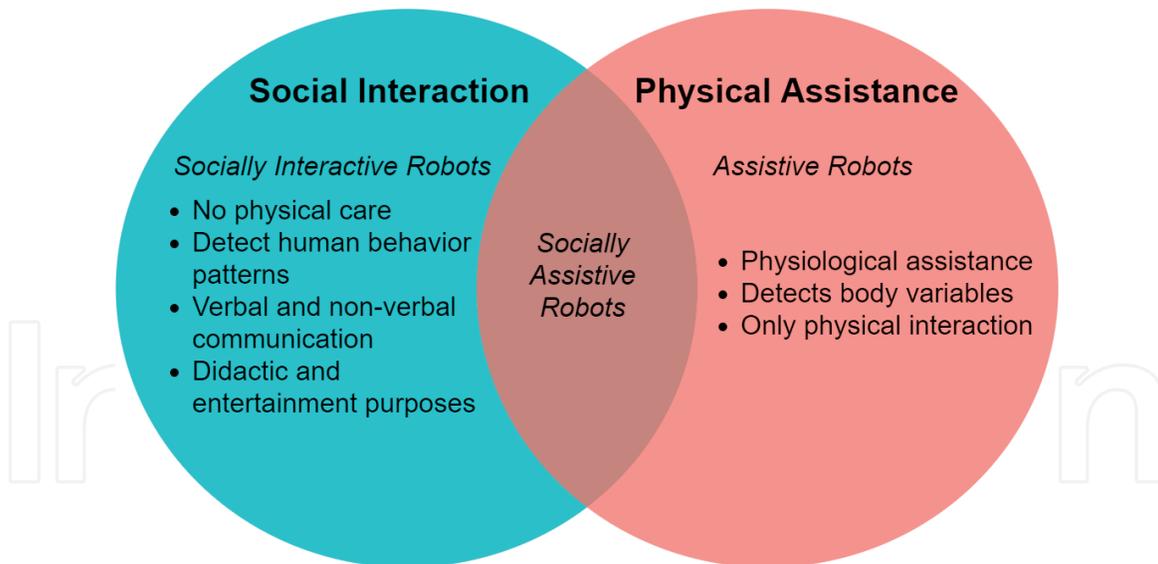


Figure 1.
Classification of robots based on their functionality.

Finally, the combination of the two prior types is called a socially assistive robot (SAR). These robots use close and empathic interaction with the user to assist in some didactic, educational, or rehabilitation process.

SAR robots are one of the most complex types of robot since it needs to resemble human behavior as much as possible to create the image of a personality and human-like behavior [2]. These two objectives allow the platform to generate empathy with the user and develop a more efficient communication with him. Also, by adequately reacting not only to the person but the environment as well, the robot is capable of performing multiple tasks.

Among all the different applications where robotics has been implemented, healthcare could be considered the area with the most impact on its use. It is usually divided into two categories: clinical and assistance. The purpose of the robots in assistance consists of the care of post-operation to help with the patient's recovery, or even to work as a substitute for a missing function in the patient's body. Another area of interest inside the healthcare is more focused on giving support to the patient on routine activities.

In the educational field, it has been recently considered that class methodologies should have an immediate application to daily life [3]. However, it is common that teachers do not know how to create innovative activities and promote student participation. One way of dealing with this problem has been with the implementation of information and communication technologies (ICTs) to improve student inclusion and link class topics with a modern approach [4]. Unfortunately, not every docent has enough knowledge on how to use these new technologies, and the new technologies turn into distractors for the students. It is then necessary to train the teaching staff into better use of the platforms to achieve better results in class.

The following sections will describe the current situation in Mexico regarding healthcare and education and how the implementation of SAR technology has been capable of improving the quality of life of the research subjects.

2. Social situations in the Mexican population

2.1 Assistive healthcare situation in Mexico

According to the National Institute of Geography and Statistics (INEGI) of Mexico, approximately 6% of the population lives with a mental or physical

disability [5]. Every person that presents a physical, mental, and sensorial deficiency can be considered with a temporary or permanent disability. These disabilities limit their capabilities for performing one or more daily life routines and can be aggravated by social and economic factors.

There are multiple types of disability that affect different parts of the body. Generally, they are classified into three categories [6]:

- Sensorial and communication. Includes sight, hearing, and speaking disabilities.
- Motor. Consists of problems related to walking, manipulating objects, and coordination.
- Mental. It covers learning and socializing difficulties.

From these three categories, the motor disability is more frequent on the economically active population, while the other two types are more prone to appear in younger people [5].

Occupational therapy is defined as a client-centered health profession that promotes health and well-being through occupation, enabling people to participate in daily life activities [7]. At the same time, the World Federation of Occupational Therapists (WFOT) states that the use of assistive technology promotes independence in the patient, facilitating his participation in daily life routines [8].

In recent years, the implementation of socially assistive robots has been more frequent in Mexico, particularly during therapies with children with autistic spectrum, older people, and people with a motor disability. During these therapies, the behaviors of both patient and robot are observed during the performance of different occupational activities. Unfortunately, despite the promising results, there are still difficulties with a broader implementation due to economic restrictions.

Another occupational therapy study was held by the Physics and Rehabilitation National Medical Center. In this case, they studied how to detect patients with a vascular brain disease and determine if he was a viable candidate for robotic rehabilitation [9].

2.2 Educational perspective from elementary to high school level

Mexican education is divided into four different levels, each with its competences and topics to teach to their students [10]. For every level, there are specific topics regarding reading, mathematics, and science that every student needs to develop in society and further education levels. The primary purpose of the class methodologies applied is to develop the student's creativity and logical thinking, allowing them to structure their ideas and arguments [11].

Despite the efforts of the Mexican government to improve education levels, its performance on those three levels has been inefficient during the last years. The results of the PISA test held by the Organization for Economic Co-operation and Development (OECD) showed that Mexico has a deficient performance compared to other nations. From 77 evaluated nations, Mexico is located at 52nd, 59th, and 55th place in reading, mathematics, and science, respectively [12].

On national evaluations, it was also observed that 62% of Mexican students have a deficient performance in language and communication tasks, while 89.5% fail on mathematics [13].

Even though the use of ICTs has been implemented in several schools, there is still the necessity of training instructors to understand how to use these new technologies

properly. Depending on the scenario, level, and topics to teach, there are different ways on how to operate robotic platforms as a supportive tool for the teacher.

3. Socially assistive robotics for elderly people

3.1 Detection of physical and psychological violence

Even though the population above 75 years old has increased during the last years, there have not been enough resources to ensure a proper healthcare system in Mexico [14]. The first significant problem is that there are not enough specialists for treatment, being only one specialized geriatric for every 10,000 elders [15]. Also, it is estimated that 10.3% of older people suffer from one or more types of abuse [16].

The work described in [17] implemented a robotic platform that gave a specialization lecture to medical students about the proper care of elder patients, required during their treatments, as well as helping to detect when they present some level of abuse. This study evaluated how volume modulation, movement correction, and body language affected the effectiveness of the robotic platform when interacting with a group of medics. **Figure 2** shows an example of an informative session.

An evaluation metric was given to the students after the session to compare the performance of the students that interacted with the robot with a different group that received the same training session from a specialized geriatric. After each session, a satisfaction survey was given to every student to evaluate as well their perceptions about the use of the platform.

The results obtained from this study showed no significant difference between the evaluation and perception results obtained from the group that interacted with the robot and the regular group. As strange as it sounds, this is an excellent result since it can be concluded that a robotic platform is equally as good as a professional when explaining specific content to a group of people. It would still be necessary to control some environmental characteristics to make sure the results are as expected. However, it opens the doors for implementing these platforms in specialized training environments.



Figure 2.
Use of a robotic platform for medical students training.

4. Socially assistive robotics in education

4.1 Use of assistive robotics for physical education classes

According to the Mexican Institute of Public Health, there has been an increment of children that suffer from obesity. From 34.8% of the population between 5 and 11 years that presented that problem, the rate of children increased to 35.6% in 2018 [18]. There has been an urgency to promote physical education (PE) in elementary schools to reduce these statistics. Nevertheless, children are not interested in those classes since the methodology is tedious and does not attract their attention.

A research group used a NAO robot as a supportive tool for the teacher to increase the enthusiasm of children during physical education class [19]. The idea was to use the platform to give the instructions to the students, as well as making little demonstrations of how they needed to do the exercises.

The experimental methodology followed the standard model of a PE class, starting with basic warm-up exercises, such as rotating arms and legs, and continuing with more intense activities, like running around an area or doing squats. Finally, the class would end after a relaxation period, where both the robot and students performed different stretching exercises, as seen in **Figure 3**.

The results of this experiment showed that the robotic platform was capable of improving the attention span of the students during class while assuring that the children performed better every one of the exercises. However, it was also shown that the intervention of the instructor was needed on certain occasions since the students did not saw the platform as an authority figure. Despite the students considering the robot as a toy, the results were positive, considering that the purpose of PE class was to make more dynamic.

4.2 Science and mathematics education in elementary school

A critical feature that elementary school needs to develop on their students is the ability to use mathematical and logical thinking in daily life situations. For this



Figure 3.
Physical education class with the support of a robotic platform.

reason, a NAO robot was used to create brief experiments regarding whole number fractions, sound propagation, and operations with the metric system [19].

The idea of the experiments was that the explanations and activities could be given by a robotic platform or by the teaching staff. Also, an observation protocol was implemented to analyze seven characteristics of student behavior:

1. Concentration (precision)
2. Concentration (recall)
3. Habituation
4. Non-habituation
5. Distraction
6. Task enthusiasm
7. Task motivation

For every session and experiment, the students were required to follow the instructions given by an instructor or the robot, and its performance was then measured with the behavior scale. Each session was composed of a theoretical explanation, a practical exercise, a final evaluation for the students about the given topic, and a time for questions and answers.

The exercise with fractions included a visual exercise, where the teacher or the robot would show a geometric figure divided by a certain number of colored parts and with blank spaces. After showing the image, the students were questioned about how many spaces were missing to complete the figure and then which fraction represented that portion.

For the sound propagation experiment, the teacher or the robot would work as a receiver, while the student would be the transmitter of a message. The idea was to say a phrase to the receiver at a certain distance and determine if the message was received. In the affirmative case, the student would increment the distance with the teacher or the robot and repeat the exercise until they fail to receive the phrase. When the instructor or robot was not capable of hearing, the student was asked to use a paper cone to transmit the message again and verify if, in that case, the message was transmitted successfully.

The exercise of metric system evaluation is shown in **Figure 4**. In this case, a two-meter band was used as a reference for putting the robotic platform at the beginning of the track. The students were required to use 20-cm bands to determine how many were required in order for the robot to move a particular distance.

The results obtained from these experiments demonstrated that the students showed a better learning process when using the robotic platform as a reference during the experiments than the case where the teaching staff was the only one interacting with them. Finally, a perception survey was also given to the students, where they expressed their interest in the activities and the use of a robot in class. In those questionnaires, the students showed signs of great interest. Also, during a final evaluation given to the students, it was observed how the ones that interacted with the robotic platform during the exercises achieved better scores than the ones that did not interact with the robot.



Figure 4.
Metric system evaluation with a robotic platform.

4.3 Attention span evaluation in high school students

High school students are more accustomed to the use of novel technological platforms and their use in daily life activities. For the same reason, the novelty of using robotic platforms during class may not be that interesting at first glance to them. The lack of novelty could even produce the reduction of the attention span during class. For this reason, it would be proven useful to evaluate the attention span of high school students during class, when the instructor is using a robotic platform, as illustrated in **Figure 5**.

The study described in [20] analyzes how much attention a group of high school students give during a mathematics class when the teacher uses a NAO robot.



Figure 5.
Use of a NAO robot in a high school class.

The methodology of the project was as follows: First, an electroencephalogram (EEG) equipment was used in some students during class, to obtain brain activity readings. Then, the teacher would give a pre-test to the group regarding the topic that would be given after. After the evaluation, the explanations and activities of the class were given by both the instructor and the robot, taking turns during the class to do so. The explanation procedure would continue after several classes until the topic was entirely given to the students. At the end of the last class, another evaluation was given to the students to compare their results with the first test.

The results of the group that interacted with the robot during the sessions were compared with another that received the same explanations and evaluations but without the NAO robot implementation. The EEG readings were also captured in the control group to generate the comparison as well.

While the class was given in both groups, a behavioral observation protocol was used to analyze the body behavior and attitudes of the students. Finally, at the end of the sessions, a little survey was given to every student and teaching staff that participated in the experimentation to analyze their perceptions about the use of a robotic platform during class.

The quantitative results came from filtering the EEG readings of the students to acquire the alpha and beta brain wave activity [21]. These two signals indicate the relaxation and concentration periods of a human being, allowing to determine in which moments the student was paying attention and to which parts of the class. The qualitative results came from the analysis of an Auzmendi attitude scale [22] that evaluates the anxiety, utility, motivation, and confidence the student shows during class.

By comparing both results, it was concluded that a robotic platform is capable of improving the attention span of students during class. However, it was also noticed that the attention was given most of the time to the robot's activities rather than the explanation, so a change in the class methodology and robot implementation is due.

4.3.1 Deployment considerations

The different situations described earlier clearly state that the use of SAR platforms in both healthcare and education improves the direct population that interacts with this technology. However, it is still needed to evaluate the feasibility of extending the use of these platforms nationwide.

According to the last survey of INEGI regarding the number of schools of different levels (from preschool to high school) [23], in 2018, there was a total of 244,117 schools around the country, from which 85.11% represents the public school system (see **Table 1** for the school distribution according to the educational level). Considering that public education covers 87.98% of Mexican students, it can be assumed that the financial cost of the government to implement these platforms would be extremely high. It would be necessary then to search for the collaboration between the government and enterprise to finance the implementation of these platforms in every single school.

Another point in consideration is the training of the personnel. Since the teaching staff is not accustomed to using these technologies, trained personnel need to instruct them about the correct use of the platforms, as well as how they can be implemented into their educational curricula effectively. In this case, the problem would be the lack of trained people, since the use of SAR platforms is relatively new in Mexico.

It should probably take around 12 years to develop a national implementation program that covers the creation of collaboration projects between the government

Educational level	Financial support	Number of schools	Number of students
Preschool	Public	73,574	4,139,977
	Private	16,005	751,025
Elementary	Public	87,756	12,678,241
	Private	9164	1,341,963
Secondary	Public	34,293	5,939,235
	Private	5396	597,026
High school	Public	12,138	4,237,524
	Private	5791	999,479

Table 1.
Number of schools in Mexico [23].

and enterprise, the acquisition of enough platforms to cover national population, the training of engineers for the platform manipulation and methodology design, and the training of the teaching staff of every school personnel.

The use of SAR platforms in the Mexican healthcare system is a little more complex to achieve. Since last year's change of administration, the healthcare system in Mexico has sustained multiple structural changes. It would then be necessary to wait at least 3 years until the new system is sufficiently accomplished to start considering the use of SAR technologies to support medical labor. At the same time, there are other problems regarding the number of medical professionals and medical access that made the suggestion of SAR platforms difficult. Nevertheless, those aspects are out of the scope of this chapter.

It can be said generally that the use of SAR technologies in Mexico is still in the phase of experimental evaluation, where these platforms are being used in particular situations to evaluate the future possibility of national implementation.

5. Conclusions

The different scenarios mentioned in this chapter show the importance that has been given to socially assistive robots in both occupational therapy sessions and educational purposes. The few examples show promising results, as well as the desire of researchers to continue evaluating how these platforms are capable of improving the quality of life of the population in different areas. However, it is still necessary to mention the obstacles that still need to be solved in the future.

The first problem is that currently, robotic platforms, as the ones mentioned through the chapter, are expensive, making it difficult for different national institutions to acquire one platform. At the same time, there are not enough people capable of operating and giving maintenance to the robot, which transforms the platform into obsolete after some time.

Another difficulty presented in this work is that every reference and experiment mentioned was only experimental. Hence, only a small population is capable of benefiting from the use of the platform. A socially assistive robot will only be utterly efficient until most of the population benefits from its use. The idea is to use these platforms to improve the quality of life of everyone. Unfortunately, it is still necessary to develop economic and social policies besides the technological that befits the use of such inventions.

Even though the use of robotic platforms is becoming more usual, there are still areas of opportunity that need to be considered before using this technology regularly. However, it does not mean that the advancements achieved so far are less critical. On the contrary, these studies demonstrate the feasibility of using robotics in a more human-like way, improving the way we communicate and perform our duties in society.

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