A Way to Promote the Development of Autistic Teenagers Through Programming of a Humanoid Robot Platform

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***Abstract*—This paper presents the design process and results of workshops to improve the social skills of teenagers with a diagnosis of Asperger. The workshops were based on the programming process of social behavior by using the platform of humanoid robot (NAO robot). The development of workshops was conducted by interdisciplinary team and conducted by students from Mechatronics Engineering and other disciplines. The methodology and results are described considering experiences and recommendations to improve this pilot program.**

Keywords—Social skills; Robot Nao; students Mechatronics engineering; Asperger ; Autism; AspTec.

I. INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by impaired social interaction, variability in verbal and non-verbal communication and restricted and repetitive behavior (1). Asperger condition is part of ASD, according to the American Psychiatric Association's Diagnosis and Statistical Manual of Mental Disorders (DSM-5). This condition manifests no delay in language acquisition and more autonomy within the classification of ASD (2). However, Asperger diagnosis sometimes is not easy to define. This happens because is not a visible condition and, in other cases, is difficult to establish a right diagnosis for lack of specialists in the topic (3). On the other hand, children and teenagers that have this condition suffer, frequently, prejudice and stigma from the society. This situation causes social problems when child, teenagers or adult start interacting in groups and it can impair their mental health in the long term (4). They usually experiment depression and anxiety (5). These are the determining factors that increase vulnerability in people with Asperger, because the exclusion in different levels affect in personal, educational (6) and economic development (7).

Nowadays, research is being done in Autism in diverse fields of the knowledge from the biological perspective to technological supports for a better inclusion within society. For the case of Asperger condition, researchers had developed workshops in different areas to integrate them into groups of common interest. Some of these workshops are related to artistic or technology topics, as for example: development of music, photography, software applications, programming by Lego robots, scratch and others according to (8) and (9). The results of these studies show the high capacities of people with Asperger to systematize processes (10). According to this, people with conditions usually receive recommendations to study careers of environment predictive and less social interaction as sciences or engineering. However, the trends indicate the need to increase social skills for a better labor development (11). Therefore, this paper presents the results of the Project called "Co-creando Asptec: Talleres de adolescentes" (Workshops for teenagers with autistic spectrum disorder), where the main goal of these workshops were to improve social skills by programming a robotic platform(NAO robot) in order to use the process of systematizing human behavior .

This research was an initiative of students and professors of Mechatronics Engineering and it was financially supported by the Academic Direction of Social Responsibility (DARS) of the Pontifical Catholic University of Peru. All the workshops were designed and supported by an interdisciplinary team (students and professionals) taking into consideration the perspective from Electronics, Psychology, Industrial Design, Therapeutic rehabilitation and Mechatronics. The activities of the workshops were focused on developing the skills for programming a robot making use of the information research, logical thinking and personal skills; since some researchers mention (12), (13) that people with ASD present a greater predisposition towards technology. Furthermore, the experience of students in all the implementation process was a challenge for them.

II. METHOD

Case study and group session were the approaches used on this project. The participants were seven teenagers among fourteen and nineteen years old with diagnosis of Asperger condition. Six sessions were conducted with duration of two hours once a week. The workshops were developed at the facilities of the Pontifical Catholic University from February to March (vacations period of high school and the university).

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A. *Profile of teenagers participants*

The project developed a collaborative work with seven teenagers in a pilot program of workshops. The participants were invited through the communication between Group ASPTEC and EITA Center (Equipment of research and treatment of Asperger and Autism). All the participants were informed and their parents signed a permission document in order to take part of the workshop.

It is important to mention that most of the participants had some experiences of bullying during school and because of that one of them changed of type of education. Nonetheless, all of them have expectations to pursue studies to get a higher education. Other specific and important characteristics are shown in Table I.

TABLE I. PARTICIPANTS INFORMATION

ID. participants	Characteristics			
	Age	*Gender*	*Education level*	*Main interests*
D1	14	Female	High school	Make Youtube videos and technology
D2	14	male	High school	Cine, arts and technology
D3	14	male	High school	Technology
D4	15	male	High school	Technology
D5	16	male	High school	Technology
D6	17	male	High school	History and Video games
D7	19	male	Completed High school	Technology and Robotics

B. *Profile of assistance in workshop*

For the implementation of workshops, the participants were separated into groups for the practical applications. All the groups had an instructor who was guiding them personally. The instructors were students of Mechatronic Engineering of PUCP. Furthermore, a psychologist from the EITA center attended all sessions in order to monitor the activities and observe the behavior of the participants. The students of Mechatronics that participated as instructors were mostly enrolled in their last year of studies. Their average age was 21 years with a standard deviation of 1.08. All of them was invited for this experience because they manifested their social vocation and interest in maker communities, research or creative activities.

C. *Materials*

Robot NAO and software Choregraphe were used for all workshops. Some description is done in the following lines.

Robot Nao is a humanoid robot platform of 58 cm in height. Nao robot has 25 degrees of freedom and inertial sensors for control balance and the transition of positions. This robot is equipped with leds, tactile sensors, sonars, four directional microphones, loudspeakers and two cameras of high resolution. All of these components contribute to an interactive experience with this platform.

Fig. 1. Nao robots at PUCP used in workshops

Choregraphe is a multi-platform desktop application creates by Aldebaran robotics for generating movement animations, interactive dialogs, and behavior. This software is intuitive, and is possible to learn about programming in different levels because uses graphic instructions and python language.

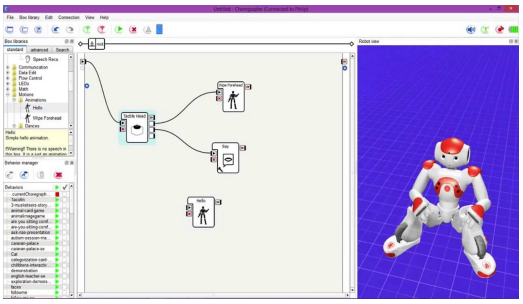

Fig. 2. Software Choregraphe

III. DESIGN AND CHARACTERISTICS OF THE ROBOTIC WORKSHOPS

A. *Perspective of Asperger condition*

At the beginning of this proposal, it was conducted a systematic research of the condition and it was collected the professional opinion of specialists in the field, in order to define the humanistic and theoretical foundations for the activities. The design of this methodology is based on the psychological current of Cognitive - Behavioral work. Moreover; it is also based on the Theory of mind (14) and Theory of systematization and empathy (10), with the target to value the Neurodiversity in Autism (15).

Level I, the way in which they perceive everything external sensory stimulus and the intensity with which these affect them. Also, characteristics of their speech (Echolalia, repetitive speech or idiosyncratic speech). Level II, reflects the characteristics of their behavior that contribute to its personality. Such as the need for predictive systems and systematize processes that are interpreted as inflexibility to changes. Also the fixing by specific topics (restricted interests) and the perseverance that they demonstrate in these topics. Level III, the challenges in the social development. At the levels I and II must be added the concepts of the theory of mind: the ability to interpret the intentions of the other. What

for many persons may be innate empathy, for them must be systematized beforehand. The levels I and II could explain how they perceive their environment and thinking. In this way, this influences how they socialize, presenting a challenge in developing social skills.

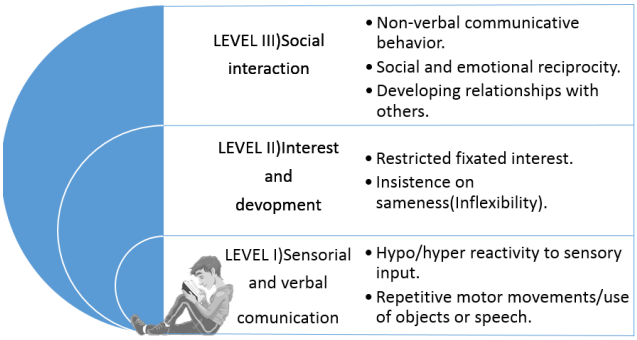

Fig. 3. Diagram of development challenges in Asperger

B. *Skills development through workshops*

After understanding the theoretical features of the Asperger condition, it decided to work with teenagers emphasizing the development of social skills and vocational guidance in areas of STEAM (Science, Technology, Engineering, Arts, and Mathematics). One of the main targets was to develop an initial ability for doing research in order to familiarize their restricted interests by an academic method. Furthermore, the workshops had specific targets for the academic training such as:

1) For teenagers participants:

a) Improve their teamwork skills through an interaction with a group with common interests.

b) Learn programming techniques for systematization of social behavior by using a Nao robot, considering their observations and including their personal interests.

c) Let them to find by programming a creative way to develop their skills for systematization.

d) Show through academic experience some of the STEAM areas and promote a vocationally interest on these areas.

e) Develop a university experience inside campus.

f) Strengthen the self-esteem of adolescents.

2) For students of Mechatronics:

a) Develop programming and teaching skills through topics of robotics.

b) Promote an interdisciplinary work among students.

c) Develop skills of empathy toward the problems of their environment like human analysis of the problems.

d) Create a space of critical analysis about the Asperger condition.

e) Learn about the features of the condition of the ASD.

f) Be a means of disseminating the experience through: information, research, thesis or other work.

C. *Design experience for teenagers participants*

The content, the number and the time of the sessions was designed taking into consideration the objectives and the schema of characteristics of condition shown in Fig.3. It was used visual supports to make the sequence of daily activities predictable and understandable. Also, it was considered the attendance of the psychologist in the majority of sessions to advise the guides about the behavior of participants, only when it was necessary. Finally, the program was adjusted according to the needs of adolescents during each session and also it was conducted academic visits inside campus in congruity with it.

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The workshops started in February 2016 (during vacation period at high school and university) and finished in March (start of the academic year). Because of the limitations of time the team designed six sessions with duration of two hours once per week. At these sessions were considered a break interval of 15 minutes and 30 minutes for presentations of visitors and tours to the facilities within the university in order to offer a vocational experience.

The selected methodology included a theoretical introduction reinforced continuously with images and examples, considering a clear and direct language (30 min), at the end of each session it was proposed a challenge related to the topic of the day and it was given in advance a graphical description of the next session.

D. *Workshop structure*

The workshops were designed for working in groups, considering changing their members only until session 4. Each group had an advisor. The contents of the six workshop sessions as well as the university activities are detailed in Table II. At the first session, the topic structure was focused to bring topics of Robotics with orientation towards social robotics. Also, it was explained the technical characteristics of the Robot Nao, its appropriate use and it was provided a first approach to software Choregraphe. After that, the guides were introduced to the participants and they had around 15 minutes to know each other and propose ideas in the field of social robotics. This session concluded with the presentation of a student of the master in Social robotics, who gave examples of

projects in the laboratories of the University of Tsukuba in Japan.

TABLE II. WORKSHOP ACTIVITIES

Session	*Content*	*University Activity*
1	Introduction of Social Robotics and introduction to Nao Robot	Presentation of a guest student of the master's degree of social Robotics from the University of Tsukuba
2	Introduction to software Choregraphe	Visit to the laboratory of Biomechanics and applied robotics(GIRAB)
3	Developing flow charts	Visit to the laboratory of manufacturing technology 3D(Sala VEO)
4	Creating emotions and social behavior with Nao	Visit to the center of advanced technologies for manufacturing(CETAM)
5	Development of a routine of interest with the Robot	Presentation of the group of videogame development(AVATAR)
6	Final presentation of projects developed using Nao Robot	Closing ceremony

The second session was oriented to use the software Choregraphe and program movements of Nao robot. The challenge of the day was to simulate physical social behaviors (non-verbal language) with the robot. At the end of the session, the members of the Group GIRAB explained their research in the field of Biomechanics and robotics. The third session began with a guided visit to VEO laboratory. At this session, some modifications of the methodology were done considering recommendations of the project members as a result of sessions 1 and 2. Therefore, this session was conducted without the use of computers to explain concepts for creating flow charts and algorithms. It used examples of their daily activities and their own interests. Also, it was presented an introduction of programming languages. Finally, at the end of this session, each participant had to demonstrate how to make a flow chart of some of their themes of interest.

The fourth session started with a guided visit to the Center of advanced technologies in manufacturing. Then adolescents used the Nao robot and practiced what they learned in the previous sessions. The final work of this session was the development of a routine based on the creation of emotions and social behavior with the NAO robot.

The fifth working session was focused on the development of a personal project, with the use of the robot, in accordance to the interests of each adolescent. The closing topic at this session was the development of video games. Finally, in the last session, the participants ended up details of their projects and they made an oral presentation of their proposals for their peers, parents, instructor and the Program Chair of the Mechatronics Engineering Program.

E. Design experience for intructors

The workshops were designed considering that all the engineering students that worked as instructors could have an interdisciplinary experience and also that they could develop technical skills related to programming and management.

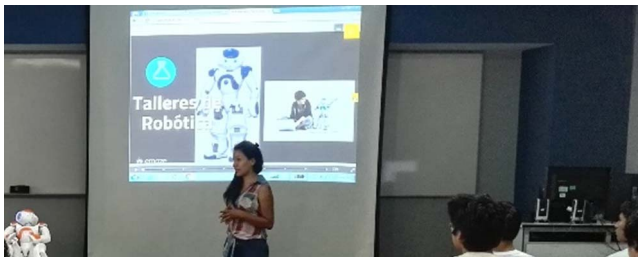

Fig. 4. Theoretical lesson taught by Mechatronic student

Fig. 5. Collaborative work among student of mechatronics and adolescents

Furthermore, they could have approach to the needs of our society and how it could be solved by engineering tools. It was designed a training process from January to March with one session per week. This process allowed the creation of a here was created a “community of development”, which involved professionals and students of careers such as , Psychology, Industrial Design, Computer science, Mechanical Engineering, Electronic Engineering and Mechatronics Engineering. This group developed different activities like research, discussion and suggest ideas. They were trained in the use of the Nao robot as well as in the understanding of the characteristics of the Asperger and autism condition. All trained instructors participated in meetings at the end of each session in order to give their opinions and suggestions for improving the workshops. It was expected that instructors could develop their humanistic perspective, technical skills and project management. Therefore, all this knowledge was expected to contribute with an integral education.

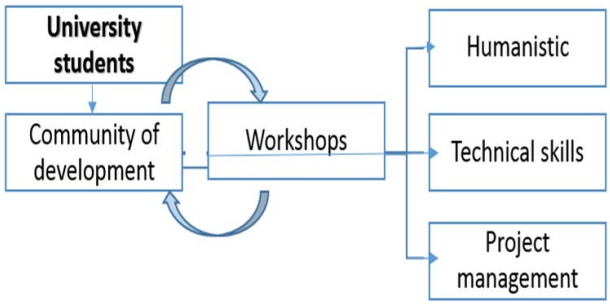

Fig. 6. Process of work and results expected for the students of engineering

IV. RESULTS

The results of the workshops are qualitative and they were obtained from two sources: psychologist report and instructors report. The report of the psychologist comes from an observation process during each session and after workshops at therapy sessions. For the reports of the instructors it was considered their observations from the technical point of view and their own experience related to social interaction. All reports were systematized and analyzed according to the specific goals of the intervention. Those results are qualitative. At the beginning, the project tried to evaluate social abilities and executive function by using the Test Brief (Before and after the intervention). This evaluation was developed by the parents of teenagers. However, the revealed result was not validated by the evaluator because due to familiar slants inside the analysis. Therefore, the team decided to make a qualitative evaluation.

A. Psychological report of Teenagers

The psychological report was divided in two parts: First, social abilities and second; attention, learning and university experience.

1) Social abilities :

a) Interaction with robotic system: The proposal to program a robot appeared to be attractive to all adolescents and they felt comfortable with the technological environment. Those who had more interest in the technology were more motivated. It was difficult for some participants to familiarize themselves with the program. The robotic system became an excuse that allowed the interaction between adolescents and the facilitators.

b) Interaction of the adolescents between themselves: The participants found similar interests with peers but they had some difficulties to start or keep up communication for interacting in groups.However, because of they shared same interest on same topics they started an initial conversations and discussions. The participants made new friends in the workshop. In the last workshop participants communicated to each other with confidence; also they made groups spontaneously.

g) Interaction of adolescents with the instructors: The sessions generated a link between instructors and participants. The characteristics of the instructors (personality, age, interests) made possible the link. At this time, adolescents shared their interests. The workshop became a space where adolescents shared their everyday concerns, their ideas and emotions. The instructors marked guidelines to ask questions and express an opinion in an appropriate manner, at the appropriate time. They acted as effective guides to develop conversational skills. Sometimes, the instructors expressed that they had difficulties to understand teenagers and be understood by them.

2) Attention, learning and university experience:

a) Attention: The use of computers and the robotic systems kept attention of the participants and there were no significant problems to accomplish the tasks. Only in one case (D1), the interest for the realization of videos (their favorite hobby) prevented that pay attention to the activities of the workshop. In the first workshops, two teenagers (D1 and D5) did not follow the indications of the instructor, so that there was a more personal follow up. The dynamics of the workshops improved when the instructors addressed more closely the activities.

b) Learning: The learning rhythm was variable. The speed directly affected the attention. The methodology was adapted to the characteristics of each staff learning. Overall it depended on the speed of learning and specific interests. The link between the instructor and the teenager was directly proportional to the speed of learning. The participant (D6), had significant learning difficulties, he said that he had headaches because of the amount of information received. In this case, the session was conducted according to his topic of interest and he worked step by step. Also, the use of a robotic system, allowed to observe the specific results of its learning which maintained its motivation and effort. Positive learning experiences allowed the participants to improve their self-esteem and security, and became more tolerant to the frustration.

c) University experience: The visits to the 3D print room (VEO laboratory) and the game design motivated to the participants to investigate about the subject. In the case of (D1) the presentation about social robotics was one of the few times in which he paid greater attention to what was explained. During the closing event (D1) and (D6) showed security and happiness for the results of their projects. One participant, (D6), forgot many times the talks by turns talking about their topics of interest, history, during classes. However, he proposed many ideas and projects in the field of robotics. Most of them expressed high motivation by the fields of research at the university. Table III shows a summary of skills developed for each participant and what kind of personal interests they have.

TABLE III. SKILLS DEVELOPED FOR EACH PARTICIPANT

ID	**Social abilities**		**Attention, learning and university experience**			**Personal interests**
	Peers	***instructors***	***A***	***L***	***UE***	***Recognizes their skills***
D1	-	-	-	-	X	make videos
D2	X	X	X	X	X	technology
D3	X	X	X	X	X	technology
D4	X	X	X	X	X	technology
D5	X	X	X	X	X	technology
D6	X	X	-	-	X	History
D7	X	X	X	X	X	technology

B. *University students reports*

The pilot program was initially proposed to work in two groups. However, because of the variations in the learning process the sessions were made in four groups. For this, two instructors were incorporated to the group. At the first session the instructors had doubts about how to act in cases where (D1) and (D6) showed less interest. To solve this problem, the project counted with the support of a specialist in therapy and rehabilitation for Autism, so that (D1) could follow the sessions. During the stage of training and guided tours, university students showed greater interest in the laboratories. Most of them they did not know that those laboratories exist. Also, most of the instructors, when they finished earlier the raised activities shared information about technological topics of their own interests with the adolescents. The students improved their presentation skills in the progress of the sessions. The sessions where participants elaborated a flow chart had a meaningful learning, this happened because it is related to the daily activities. According to this, the participants started to link social activities with logical schemas. At the end of the workshops the instructors explained part of the projects in which they worked and described their experiences to strength the sense of well-being of adolescents in order to help them to accomplish their projects.

V. CONCLUSIONS

The developed workshops allowed us to identify that promoting group activity, where sharing personal interest plays an important role, it could be essential for the development of social skills for teenagers with Asperger condition. Furthermore, the acquisition of knowledge in programming was closely linked to the self-esteem, learning style and parental support. Also, the learning process through projects of their own interest had optimal results. On the other hand, engineering students expressed greater empathy toward disability issues after the experience. Also, they showed greater attention in learning skills and techniques when the aim was to teach more people. Finally, the pilot program, had a very short duration and monitoring to ensure the connection between the programming of social behaviors and the acquisition of these.

VI. FUTURE WORK

The team of this project expects to develop more workshops that can include topics as 3D printing, CAD modeling, and deeper programming of robots as part of therapy activities. Furthermore, the team will develop a quantitative evaluation for future workshops.

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