INCLUSIVE PROJECTS IN SCIENCE AND TECHNOLOGY TO SECONDARY AND HIGHER EDUCATION

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Abstract

The purpose of this work is to bring science and technology and its applicability closer to secondary school and university students through the development of cooperative projects with people with functional and cognitive diversity. Through a teaching and learning methodology based on inclusive projects, professors from Higher Education aim to promote scientific and technological vocations and involve people with diversity in the advances in science and technology while making their condition visible to young people. This work shows both qualitative and quantitative indicators that allow us to evaluate the impact of those proposals. The degree of satisfaction of all the agents involved is very high, not only with the teaching and learning but also with the quality of the solutions developed to meet the needs of those people with diversity. The incorporation of projects based on both socially inclusive technological challenges and fairs increases motivation, participation and interest in science and technology, as we will demonstrate from obtained results. In addition, we would like to point out that these proposals mainly achieve three different sustainable development goals: number 4 (quality education), number 10 (reduction of inequalities) and number 12 (responsible consumption and production).

Keywords: *Secondary education, higher education, science and technology education, new learning and teaching models, inclusive education.*

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1. Introduction

The development of transversal competencies requires education in citizenship and the inclusion in teaching of activities aimed at the mastery of basic social skills (Sá & Serpa, 2018), such as effective communication, respect, social inclusion or assertiveness. However, there are very few subjects in our Secondary and Higher Education systems in which collaborative learning activities with solidarity objectives are developed, especially in those of a technological nature. Advances in science and technology have had a major impact on the daily lives of citizens. In particular, progress in the field of Information and Communication Technologies (ICT) has revolutionized lifestyles and the way of "doing" in today's society (Vial, 2021). Technological evolution has also brought about positive changes in ICT accessibility; however, this progress has been less than that developed for citizens in general. Thus, the phenomenon known as the "technology gap" continues to exist, which has a negative impact on equal opportunities for people in vulnerable situations, such as people with disabilities.

On the one hand, in many cases, the lack of knowledge of the developers of technological tools and of the citizens themselves about the capabilities and needs of people with disabilities, implies the absence of participation of these people in the processes of design, development and validation of technology. On the other hand, most of these technologies do not meet the requirements of universal design and, therefore, people with disabilities cannot participate on equal terms in current technological progress. Responsible production and consumption is also not encouraged, making sustainable technology a challenge for both producers and consumers.

Service-learning is an innovative teaching methodology that seeks the acquisition of not only academic competences, but also those transversal sills, through a service to the community, generally in their immediate environment (Castro et al, 2020; Conway et al, 2009; Tapia, 2000; Tejada, 2013). In an economic situation like the current one, solidarity and awareness of the needs and problems of others is

even more important (Tapia, 2000; Tapia & Peregalli, 2020), trying to reduce the digital gap to counteract the social distancing it causes (Waldner et al., 2012).

In this paper, we present two inclusive experiences based on micro-projects of science and technology that response to needs of people with diversity to provide them with solutions through works developed by secondary and higher students, respectively. The main objective of both proposals is to increase the knowledge and skills in the field of science and technology of non-university students (secondary, high school and vocational training), and also of university students, promoting Science, Technology, Engineering and Mathematics (STEM) vocations through active and collaborative participation in the development of technological solutions for people with diversity. In this way, the traditional education methodologies are transformed into learning and service, thus promoting a new model focused not only on contents but also on values. On the other hand, since fairs or other similar events constitute a didactic resource with which, in a playful way, we can increase the motivation and participation of the attending public (García-Molina, 2011; FECYT, 2018), both proposals contemplate the participation or realization of any event of this type, with the purpose of bringing science and technology closer to these disadvantaged groups. In this way, we want to favour their integration in a digital world that often excludes them while promoting the acquisition of those transversal competences in our students.

This paper is organized as follows. This section introduces the need of incorporating inclusive projects in science and technology to Secondary and Higher Education. Section 2 details the most important design aspects of both experiences. Section 3 shows the goals of both proposals and the methodology to achieve them. Section 4 shows the main results obtained from these inclusive projects and Section 5 includes the conclusions drawn from the work done.

2. Design

This paper shows two experiences developed in the 2021/2022 academic year in which, through micro-projects, we answer to needs of users with functional and/or cognitive diversity in both contexts of the Secondary and Higher Education.

The experience in Secondary Education runs from November 2021 to June 2021. It is based on the realization of projects by secondary students. These technological challenges (we will referred to them in the following as micro-projects) are posed to promote opportunities and learning related to science (hypothesis, observation, problem solving and overcoming challenges), innovation in technology (experimentation with different technologies, creativity, development of technological solutions) and the social utility of science (adaptation and resolution of challenges according to the capabilities and needs of people with diversity and obtaining technology that has a direct impact on the quality of life of this population). This collaborative experience is proposed between the University of A Coruña (through the Centre for Information and Communications Technology Research-CITIC- and its Social Council), the “Asociación de Padres de Personal con Parálisis Cerebral” of A Coruña (ASPACE Coruña) and secondary schools in the area. Nearly 200 secondary students and 26 people with cerebral palsy served by professionals from that local organization were participating in these micro-projects supervised by about 15 higher researchers and funded by the national project "Talentos inclusivos" (Inclusive talents, ref. FCT-20-16226).

The experience in Higher Education runs from October 2021 to March 2022. It is developed in the context of the Technology subject for teachers of Compulsory Secondary Education (ESO) of the University Master's Degree in Secondary Education Teaching, of the Technology itinerary. The learning outcomes of this course are the knowledge of the contents of Technology, object of teaching and learning in ESO and of the situations of the environment suitable for the application of these contents. The teaching group is made up of 19 students with a technical profile (engineers, architects, mathematics graduates) and two professors. The collaborating entity, to which the service is destined, is a non-profit association of our environment, the "Asociación de Padres de Personas con Trastorno de Espectro Autista" (ASPANAES), dedicated to the care of people with this disorder and their families. This entity serves more than 500 family units and its reach in social networks is more than 250,000 users. Seventeen users of this entity, accompanied by their professionals, attend in person the final event of the experience, a technology fair, although, not in person, all users of the entity who were interested in it received through those professionals a description of the micro-projects and the materials needed to carry them out.

3. Objectives and methodology

In this section we will show the objectives of both proposals, together with methods and materials necessary for achieving those objectives. First of all, we must highlight the enormous social

coverage of both experiences, since the projects involve to teachers belonging to secondary schools; people with disabilities and especially with cerebral palsy and autism, specifically, users of ASPACE Coruña and ASPANAES; technical professionals of ASPACE Coruña and ASPANAES; members of CITIC who act as tutors of the participatory groups, and society in general.

The main objective of both proposals is to increase the knowledge and skills in the field of science and technology of non-university students (secondary, high school and vocational training) and university students, promoting STEM vocations through active and collaborative participation in the development of technological solutions for people with functional and cognitive diversity. In addition, during all the activities that we will show below, we will achieve: encourage scientific-technological vocations among students from different educational levels; supporting education through the promotion of scientific and technological literacy; promote knowledge about the social utility of science; to bring the daily reality of people with disabilities closer to young people and the need for them to be proactive actors in the future in order to involve people with disabilities in the advances in science, technology and innovation; improve accessibility to ICT and the development of low-cost technological solutions based on the requirements of universal design and sustainability for people with disabilities with usefulness for their daily lives, and generate equal learning opportunities to reduce the gender gap and visualize the advantages of an inclusive technology where all the capabilities of potential users are taken into consideration.

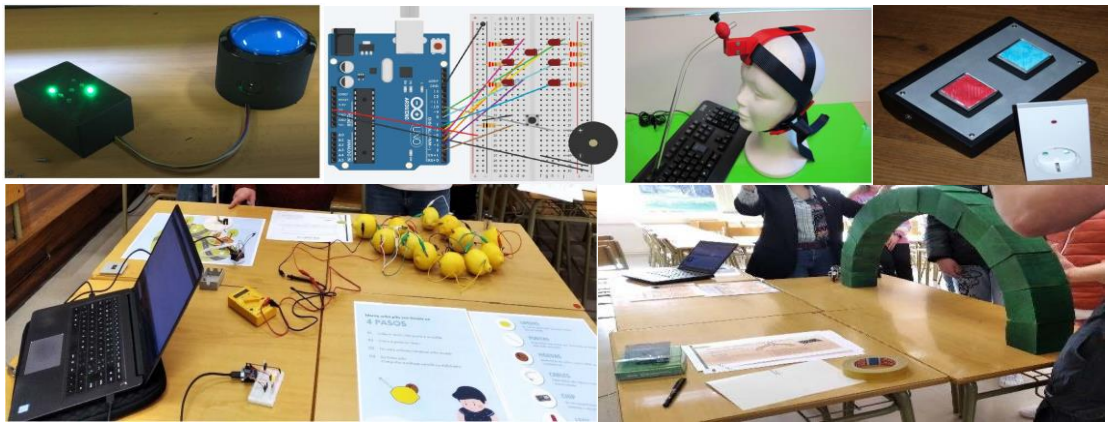
About materials for achieving such objectives, realise that it depends on the type of micro-project to be developed and existing resources in each centre, but in general we can identify the following needs: computers; webcams; Micro:bit, Arduino or similar boards; Raspberry Pi kits; home automation systems; sensors and actuators; voice assistants; drones and robots; low cost boards, with Wi-Fi and Bluetooth, and components, and so on. At the beginning of the activities, consent for participation and image dissemination was obtained from all the involved agents, except the image dissemination for ASPANAES users.

The work methodology to be followed in both experiences can be divided into these six activities of Table 1:

Table 1. Project methodology.

Activity	**Procedure**
Selection of the participating secondary schools and entities	*Open call and by interviews, e-mails and phone calls, respectively*
Formation of the student working groups in Secondary and Higher Education	*Voluntary, free size or in pairs, respectively*
Definition of technological micro-projects	*Identification of technological needs and preferences of users by entities* Projects with ASPACE Coruña and students of Secondary Education: *They were grouped into 9 categories: support products and 3D printing; access to computer, mobile and communication systems; home environment control and ASPACE; rehabilitation; alarms; work accessibility; augmentative and alternative communication systems; sensor environment control, and leisure* Projects with ASPANAES and students of Higher Education: *Control, robotics and scientific experiments*
Project development	*Each working team chooses the micro-project that best suits its circumstances and interests. Using User-Centred Design, we work collaboratively among all the agents involved (professionals and users of the entities, teaching staff and students) holding virtual meetings and workshops and sharing material and progress through e-mail and a web page in SharePoint. The final objects trying to be sustainable*
Work presentation	*Public presentation event and technology fair, in Secondary and Higher Education, respectively*
Project assessment	*Service: Self-developed surveys and, in the case of service users, QUEST (© L. Demers, R. Weiss-Lambrou, B. Ska, 2000 - Spanish version by João Guerreiro 2013 (rev. 2020)) is also used* *Learning: Self-developed rubrics*

Figure 1. Micro-projects in the Secondary Education (up) and Higher Education (down).



4. Results

Figure 1 shows the pictures of some of the micro-projects developed in both experiences.

The assessment mechanisms used were both quantitative and qualitative. The former focused on counting the number of participants and the number of micro-projects carried out. These data were collected during the formation of the student working groups and in the final work presentation activities, in which the collaborative groups publicly presented the solutions finally achieved. The qualitative impact assessment mechanisms focus on the results obtained on a series of scales aimed at the different groups participating in the project: users of both entities, professionals from these entities, secondary school teachers and students, and university professors and students.

Regarding the gender of the participants, women do not reach 40% of the total, being the professionals of the entities the only sector in which women predominate. Other results from the quantitative assessment are shown in Table 2.

Table 2. Quantitative project assessment.

ACADEMIC IMPACT	**RESULTS**
Projects with ASPACE Coruña and students of Secondary Education:	
No. of participating schools	10
No. of participating students	193
No. of participating teachers	14
No. of participating professors (CITIC researchers)	15
No. of ASPACE Coruña participating users	26
No. of ASPACE Coruña participating professionals	5
No. of completed micro-projects	24
Projects with ASPANAES and students of Higher Education:	
No. of participating students	19
No. of participating professors (CITIC researchers)	2
No. of ASPANAES participating users	17
No. of ASPANAES participating professionals	6
No. of completed micro-projects	9
ECONOMIC IMPACT	**RESULTS**
Cost-benefit of solution compared to commercial device	Saving of at least 85%.
SOCIAL IMPACT	**RESULTS**
Participation in social networks	Yes
Projects with ASPACE Coruña and students of Secondary Education:	
No. of proposed micro-projects	44
Numerical result of the QUEST scale	4.1/5
Projects with ASPANAES and students of Higher Education:	
No. of proposed micro-projects	9

If we focus on the qualitative results, we have to say that the assessments of all the agents involved have been excellent, always higher than 4 out of 5 on the scales.

5. Discussion and conclusions

Taking into account the results of Section 4, we can say that the objectives shown in Section 3 have been achieved. These experiences also contribute to the Sustainable Development Goals (SDG) no. 4, 5, 10, 11, 12 and 17, related to education equality; gender equality; reduced inequality; sustainable cities and communities; responsible consumption and production, and partnership for the goals.

The essence of the project implies an active participation of society, represented by the group of secondary school students and teachers, as well as all those associated with ASPACE Coruña and ASPANAES, CITIC and the University of A Coruña, who have participated either directly or indirectly in the project. Taking into account this wide variety of groups, the number of people involved in the activities in each of them and the large number of people attending the work presentation and the different events and fairs, we can state that this objective has been achieved. Although the participation of women has been strengthened in selection processes and team leadership, it is low specially in the student group, but we have to take into account an important bias, derived from the still scarce presence of girls in STEM subjects. Moreover, one of the main objectives of these experiences has been to promote and awaken technological and scientific vocations among university and non-university students. By posing various technological micro-projects, it has been possible to bring students closer to a new way of doing science and technology, based on exploration and experimentation.

From a learning point of view, students in both educational stages acquire not only the technology contents of these stages, but also a series of transversal competences that will be very useful for their professional and personal development: public speaking, tolerance and respect, ability to work in groups, decision-making, critical thinking, self-learning, initiative, creativity, empathy, responsible consumption, solidarity and knowledge of diversity, always from the perspective of learning to learn, from mistakes and from those who are different.

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