ROBOSTEAMSEN Project – Training SEN teachers to use robotics for fostering STEAM and develop computational thinking

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Miguel Á. Conde
Dept. of Mechanics, Computer Science and Aerospace Engineering
Universidad de León
León, Spain
mcong@unileon.es

Francisco J. Rodríguez-Sedano
Dept. Electrical, Systems and Automation Engineering
Universidad de León
León, Spain
fjrods@unileon.es

Francisco J. García-Peñalvo
Dpto. de Informática y Automática - IUCE
Universidad de Salamanca
Salamanca, España
fgarcia@usal.es

Jose Gonçalves
Research Centre in Digitalization and Intelligent Robotics (CeDRI)
Instituto Politécnico de Bragança
Bragança, Portugal
goncalves@ipb.pt

Ilkka Jormanainen
School of Computing
University of Eastern Finland
Joensuu, Finland
ilkka.jormanainen@uef.fi

Andrea Anzanello
Dept of Project Management
Pixel
Florence, Italy
andrea.anzanello@pixel-online.net

Jonny Filipe Ribeiro Alves
Colegio Intérnato Dos Carvalhos
Carvalhos, Portugal
jonny.alves@cic.pt

Raquel Fernández Hernández
Colegio de Educación Especial Ntra. Sra. del Sagrado Corazón de León
León, Spain
rfernandezhe@educa.jcyl.es

Alina-Andreia Ailincai
EuroEd Primary School
Lasi, Romania
alina.ailincai@euroed.ro

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***Abstract*— Our contemporary society necessitates professionals equipped with 21st-century skills. Disciplines within Science, Technology, Engineering, Arts, and Mathematics (known as STEAM) have been particularly effective in fostering these skills. However, when considering students with disabilities, especially those with intellectual or developmental disabilities (IDD), this assertion often falls short. In this context, the RoboSTEAMSEN project emerges as an initiative designed to enhance educational processes by providing teachers of IDD students with the necessary resources to promote STEAM engagement. The project proposes the use of active learning methodologies and robotics to achieve this goal. The primary objective of the project is realized through several strategies: understanding the needs of students with disabilities and adapting the use of robotics and active learning methodologies accordingly; training teachers in the use of these resources; and creating a platform to exchange experiences, resources, lessons learned, tools, case scenarios, etc., while reaching other potential stakeholders such as caregivers and policymakers. The main outcomes of the project are teacher training programs and the development of associated competencies, tools to identify and classify resources for the students, and technological platforms to ensure the sustainability of the project once it concludes.**

Keywords—Inclussion, Robots, Active learning Methodologies, Neurodiversity, Intellectual and Developmental Disabilities, Special Needs Education.

I. INTRODUCTION

In our rapidly evolving technological society, institutions and companies must adapt to meet the changing needs of users and seek professionals who are well-prepared for these challenges. It is crucial for professionals to cultivate 21st-century skills from an early age [1].

Historically, the development of such skills has been linked with STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. Evidence suggests that these disciplines not only enhance workers' performance but also bolster a country's capacity for innovation [2, 3]. This underscores the importance of encouraging an interest in STEAM among young learners and integrating STEAM principles into current educational curricula. Various initiatives, such as TACCLE3 [4] and RoboSTEAM [5], have explored these areas, while others, like W-STEM [6] and CreaSTEAM [7], have examined the potential of STEAM for inclusive education for specific groups.

However, we must not overlook individuals with disabilities. Access to STEAM disciplines for disabled persons is often challenging due to several factors: the prevalent underestimation of their abilities in STEAM fields; an inaccessible STEAM curriculum; and the limitations educators face in supporting inclusive learning [8, 9]. To address these challenges, effective approaches are needed. Robotics, for instance, has emerged as a promising tool for promoting STEAM education [10] and has shown success in teaching students with special educational needs (SEN), particularly in enhancing social skills and executive functions [11]. Nevertheless, the crucial element is not merely the use of robotics but its adaptation for people with disabilities and diverse disability types [12]. This involves equipping experts and educators with specialized robotic resources, methodologies, and tools tailored for various disabilities.

A noteworthy initiative, RoboSTEAM [13], developed methodologies, assessment tools, and resources to facilitate the integration of STEAM and the enhancement of computational thinking through robotics and physical devices. However, this project also highlighted a significant shortfall in the application of robotics and active learning methodologies for individuals with disabilities [14]. To address this issue, some members of the project team have committed to bridging this shortfall by leveraging robotics and

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active learning methodologies to enhance access to STEAM education for individuals with intellectual and developmental disabilities (IDD). RoboSTEAMSEN is designed to assist SEN teachers of students with IDD by providing them with specialized tools and strategies to cater to different IDDs. This involves understanding common IDDs and their characteristics, as well as personalizing learning through robotics and active learning methods for a diverse range of SEN teaching activities [15].

This paper describes the project proposal. Section 2 project related works, section 3 the objectives, section 4 the partnership and section 5 the proposed work-pacakages and expected results. Finally in section 6 some conclusions are posed.

II. RELATED WORKS

ROBOSTEAMSEN project addresses is complementary to several previously mentioned projects but is addressing inclusion with IDD students in a way previously not developed. This is explored through two systematic mappings one carried out considering other projects outcomes and the other considering scientific bibliography.

The first mapping involved an extensive review of projects using databases like CORDIS, the Erasmus+ Results Platform, and KEEP. Recent initiatives have advocated for STEAM approaches, such as TACCLE3 [4], RoboSTEAM [13], W-STEAM [6], and CreaSTEAM [7]. While applicable to teaching students with IDD, they do not specifically target this demographic. Some projects, like SEARCH [16] in Bulgaria and the INPhINIT PhD initiative [17], touch on inclusion but do not center on SEN teaching. Others, like BEACONING considers game applications [18] with IDD students but are not focused on the use of robotics or active leanring methodologies. There are initiatives like RIDE [19], RIDEX [20], PACE [21], CODEFROR [22], and BRAINAble [23] that encourage the use of robotics with children with IDD. Nevertheless, a conspicuous gap remains in the training of teachers on how to apply Robotics and Active Learning Methodologies specifically to promote STEAM subjects for people with IDD. While some projects target pre-school education, such as “Inclusive preschool for digital VAK” [24], and others like steam4SEN [25] offer tools and kits to create STEAM learning materials, RoboSTEAMSEN uniquely emphasizes using robotics and active learning methodologies to enhance STEM education, with a particular focus on customizing these technologies and methods for a variety of IDD.

The second mapping, considering sources such as Scopus, Web of Science, and ACM, reveals that although numerous scholarly works explore the intersection of IDD, STEAM Education, and robotics [26], most studies are case-specific and do not encompass a broad spectrum of disabilities. Only a handful, such as those by Howard et al [27] or Lamptey et al [8], address multiple disabilities like RoboSTEAMSEN, yet they lack a significant focus on teacher training and on the adaptation of resources for diverse needs.

III. OBJECTIVES

ROBOSTEAMSEN main goal is to establish a knowledge foundation for educating SEN teachers to nurture STEAM and computational thinking among individuals with IDD through the utilization of robotics and active learning techniques.

This main objective could be articulated as follows:

- Evaluate and discern the various challenges associated with STEAM education for individuals with IDD.
- Investigate and determine the necessary methodological adjustments and tool customizations that students with IDD require, according to the type and severity of their disabilities, within the framework of robotics and active learning methodologies.
- Develop practical guidelines for tailoring the application of the core resources of the project (robotics and active learning methodologies) in STEAM education specifically for students with IDD, taking into account a range of disabilities and their respective levels.
- Aggregate and disseminate a public repository of effective practices, content, and tools for implementing robotics in SEN teaching within the scope of STEAM education.
- Execute training programs for SEN teachers and conduct workshops in educational settings to propagate the adoption of these resources, methodologies, and knowledge of adaptations, ensuring the inclusion of STEAM education for individuals with IDD.
- Foster collaborative relationships between university robotics labs, robotics companies, and educational institutions dedicated to individuals with IDD, to promote knowledge exchange and resource development.

IV. PARTNERSHIP

The consortium consists of eight organizations: four higher education institutions, two general schools, a school for students with Special Educational Needs (SEN), and a technical partner. The universities involved are the Universidad de León (ULE), Instituto Politécnico de Bragança (IPB), University of Eastern Finland (UEF), and Universidad de Salamanca (USAL). Notably, UEF also participates as a school due to its inclusion of a teacher training institution. The participating general schools are Colégio Internato dos Carvalhos (CIC) and EuroEd (EED). The specialized SEN institution is CEE Nuestra Señora del Sagrado Corazón (SCO), and the technical partner is Pixel [28].

The consortium's composition is strategically based on the partners' areas of expertise and their established collaborative synergies, particularly from the RoboSTEAM project.

ULE and IPB bring extensive research experience in robotics and its application in educational settings. USAL and UEF are more focused on other fields, such as teacher education, eLearning, and the integration of STEAM. EuroEd and CIC have participated in numerous Erasmus projects, developing learning programs centered on technology. SCO is dedicated to SEN education, particularly for students with IDD, making them a critical partner. Last but not least, Pixel has extensive expertise in providing technical support for over 150 projects.

Considering the collaboration among partners in various projects, it is noteworthy that ULE, IPB, USAL, UEF, and CIC have all participated in the RoboSTEAM project [13]. UEF and USAL collaborated on the TACCLE 3 project [4], while SCO and ULE, as well as IPB and CIC, have worked

together on several local initiatives. Additionally, IPB, Pixel, and EuroEd have collaborated on several Erasmus+ projects.

In addition to these team members, the project will include 45 associate partners from the contact networks of the partners within their respective fields of expertise.

It is also worth noting that the partnership represents countries with diverse socio-economic backgrounds, a factor critical to assessing the project's outputs in various settings and ensuring that the proposed adaptations are effective across different socio-economic landscapes.

V. WORKPACKAGES

The project is divided in the 5 work packages (WP), each of them with different objectives and outcomes.

A. WP1. Project Management.

This WP is essential for any project. It includes all the tasks related to the project coordination, tasks distribution, schedule, quality assessment, risk management, budget management, etc. The WP is lead by ULE as coordinator with the support of the rest of the partners.

Some of the results expected during this WP are the Project Management Handbook, Quality Plan, Risk Management Approach, Interim and Final Reports.

B. WP2. Adapting Resources, Methodologies and Tools by IDD.

This work package (WP) is designed to equip individuals with the knowledge necessary for integrating robotics and active learning techniques across various intellectual and developmental disabilities (IDD). Its primary objectives include:

- O1. Assess the educational requirements of students with IDD by considering factors such as types of disabilities, levels of severity, age, and educational progression.
- O2. Develop a user model that leverages the aforementioned categorization to enhance personalized learning for students.
- O3. Compile and organize a collection of robotics resources and active learning strategies for use in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education, aligning them with the established classification.
- O4. Provide guidance for educators on customizing robotics and methodological tools for students with disabilities within STEAM subjects.
- O5. Test and validate the user model and categorization framework through the creation of tailored intervention strategies utilizing robotics for students with diverse disabilities.

Given these objectives, the anticipated deliverables include:

- A Comprehensive Taxonomy: This taxonomy will detail the characteristics of students with IDD, enabling the categorization of educational resources based on disability type, severity level, and other relevant criteria.
- A User Model Derived from the Taxonomy: This model will encapsulate the specific needs of students, informed by their disabilities, as delineated by the taxonomy. It aims to provide a nuanced representation of each student's requirements.
- A Collection of STEAM Education Resources and Tools: An assembly of robotics solutions and methodological instruments will be compiled and categorized using the taxonomy. This collection will serve as a foundation for creating personalized intervention adaptations in STEAM disciplines for students with various disabilities.
- Guidance for Implementing the User Model and Resource Repository: Manuals will be developed to assist teachers in utilizing the user model to profile students accurately and subsequently access the repository for resources that align with the students' needs. This guidance is crucial for adapting interventions in real-world educational settings.
- Prototype Interventions for Common IDD Scenarios: These samples will be tailored to the most prevalent circumstances encountered among students with IDD within specific STEAM disciplines, showcasing how the taxonomy and resources can be applied to meet diverse educational needs.

All deliverables will undergo a rigorous evaluation by experts in the field and be field-tested by educators in participating schools, ensuring their efficacy and applicability in enhancing the learning experiences of students with IDD.

C. WP3. Teacher training package

In this work package, the focus shifts towards empowering teachers to effectively utilize the guides and tools developed in WP2 for facilitating STEAM education among students with IDD. To achieve this, the main objectives of WP3 include:

- O1. Deepen the understanding of teachers' needs and challenges when instructing students with IDD in STEAM disciplines. This involves recognizing the specific demands and obstacles teachers face and providing them with the necessary support to address these issues.
- O2. Enhance awareness of how robotics and active learning strategies can promote STEAM education for individuals with IDD. By highlighting the benefits and practical applications of these methodologies, teachers can better appreciate their potential impact on students' learning experiences.
- O3. Facilitate the integration and customization of STEAM disciplines for students with IDD. This objective aims to provide teachers with the tools and knowledge required to adapt their teaching approaches and curriculum to meet the diverse needs of their students effectively.
- O4. Collaboratively develop training materials, including course content and workshop agendas, that are specifically designed to equip teachers with the skills and competencies needed to implement the resources and methodologies identified in WP2.

Through these objectives, WP3 seeks to build a strong foundation for teacher training, ensuring that educators are well-prepared to leverage the innovative tools and resources

developed for enhancing STEAM education among students with IDD.

WP3 aims to deliver:

- Discipline-Specific Training Programs: Creating a dedicated training program for each STEAM discipline to address the unique challenges and opportunities within each field.
- Disability-Specific Training Program: Developing a training program focused on a specific disability, offering deep insights into the educational strategies that can effectively support students with that condition.
- Online Courses: Launching several online courses to facilitate the widespread dissemination and accessibility of the training programs, ensuring that teachers from various geographical locations can benefit.
- Content Creation Templates: Providing templates for developing content for future training programs, ensuring a standardized yet flexible approach to training material development.
- Workshop Content: Preparing content for workshops aimed at training teachers in the results and methodologies developed throughout the project, with a focus on practical application and hands-on learning experiences.

These outcomes are designed to equip teachers with the knowledge, skills, and resources necessary to adapt their teaching strategies and curriculum to meet the needs of students with IDD, thereby enhancing the quality and accessibility of STEAM education for this diverse student population.

D. WP4. Technical ecosystem & Community of practice

Work Package 4 of the RoboSTEAMSEN project focuses on the crucial aspects of dissemination and sustainability of project outcomes. It aims to establish a community of practice underpinned by a robust technical ecosystem to ensure the longevity and impact of the project's resources and methodologies. The objectives of WP4 are designed to support a wide range of stakeholders, including SEN teachers, regular teachers, researchers, and decision-makers, by facilitating access to and the application of robotics and active learning methodologies within STEAM education for students with intellectual and developmental disabilities IDD. The objectives are outlined as follows:

- O1. Ensure easy access to a variety of resources developed throughout the RoboSTEAMSEN project, as well as those pre-existing, to support the application of robotics and active learning methodologies in STEAM education tailored for students with IDD. This involves creating a centralized repository or platform where these resources are readily available and easily navigable.
- O2. Provide tools and technical support necessary for the effective application of robotics and active learning methodologies in STEAM education for students with IDD. This includes offering troubleshooting, guidance, and updates on the latest developments in educational technologies and methodologies.
- O3. Develop tools to facilitate interaction and collaboration within a community comprising SEN teachers, regular teachers, researchers, and policymakers who are all focused on enhancing STEAM education for students with IDD. This objective aims to foster a dynamic and supportive community where members can share insights, experiences, and best practices.
- O4. Expand the knowledge base established by the RoboSTEAMSEN project with additional resources contributed by institutions outside the consortium. This initiative seeks to continuously enrich the project's repository with diverse and innovative materials, ensuring the platform remains a valuable and up-to-date resource for educators and researchers.

The outcomes related to this WP are:

- Design and Implementation Reports: Detailed documents defining the technological ecosystem, including the problems it addresses, the chosen technical solutions, and implementation strategies.
- Guidelines and tutorials: A collection of multimedia, video, and HTML guidelines and tutorials for system use, paying special attention to accessibility requirements to ensure the platform is user-friendly for everyone, regardless of technical expertise or disabilities. These materials will be available as in-context "help tips" and also in a dedicated section.
- Manual: A complete User Manual designed to educate interested stakeholders on using the ecosystem effectively.
- Technological Ecosystem: A comprehensive suite that includes tools for managing various user profiles, collaboration and interaction tools, and a repository for publishing resources related to the project, including those produced during the project as well as external contributions.
- Initial Resources Compilation: The inclusion of public resources produced in WP2 and WP3, as well as additional tools, resources, and methodologies to attract community interest from the outset.
- Engaged Users: A strategy to ensure the creation of a community of practice that will sustain the project's longevity. This involves connecting and engaging stakeholders interested in the topic, including those from associated partners and other networks. This effort will be coordinated with the dissemination strategy outlined in Work Package 5 (WP5).

E. WP5. Dissemination and Exploitation

The main goal of this work package is to ensure that the project partnership is committed to implementing effective dissemination and exploitation strategies. These strategies aim to maximize the project's visibility, establish conditions for its long-term sustainability, and enhance the reach and impact of its outcomes within the broader educational sector. Consequently, the project partners have committed to allocating an entire work package to the planning and execution of dissemination, sustainability, and promotional activities. These efforts are part of a cohesive strategy that will be integrated into the contractual obligations of all

participating institutions. Thus, this work package is critical for unlocking the full potential of the project.

The full execution of the work package activities is aimed at securing the following outcomes:

- Establishment of conditions to ensure the project's results are effectively utilized and remain sustainable over time.
- Extensive dissemination of the project's achievements and deliverables to target groups and beneficiaries.
- Establishment of conditions that ensure the project's outputs are utilized and remain sustainable over time.
- Development of dissemination events in each of the partnership countries to amplify the project's impact.
- Engagement of additional educational institutions to further disseminate project information to their end-users.
- Presentation of the project at national and international conferences to showcase its achievements.
- Awareness among key policy and decision-makers in the fields of education and training about the project's activities, deliverables, and outcomes, thereby facilitating their integration at a systemic level.
- The creation of web links from regular and SEN education and teacher training websites to the project's web portal and technological ecosystem.
- Media coverage to promote and publish information about the project.

VI. Conclusions

Full inclusion of individuals with IDD within our society is paramount, and education serves as a pivotal arena for achieving this goal. Technology and robotics have emerged as effective tools in facilitating such inclusion, addressing the broader societal call for not only enhancing learning for people with disabilities but also for integrating STEAM into their education and promoting STEAM fields within this community. While robotics and active learning methodologies have already proven successful in STEAM education among mainstream students, there is a compelling interest in replicating these successes with students with IDD.

However, leveraging technology to advance STEAM education for individuals with IDD necessitates tailored adaptations of resources and interventions. This requirement stems from the diverse nature of disabilities, including variations in severity, the educational integration of students across countries, their ages, and the time dedicated to learning activities. For example, the needs of a child with a mild autism spectrum disorder, who may be integrated into a regular school and capable of using technology despite communication challenges, differ significantly from those of an individual with more profound needs that may require specialized educational settings. Thus, the selection of robotics tools, methodologies, content, and the design of each learning activity must be customized to reflect the unique characteristics and context of each student. Consequently, empowering educators with the skills to make these adaptations is crucial.

In conclusion, RoboSTEAMSEN is envisioned as a transformative initiative that not only enriches the educational experiences of students with IDD through the integration of robotics and STEAM but also champions the cause of inclusive education. By developing comprehensive resources, training programs, and a supportive community of practice, RoboSTEAMSEN aspires to create a sustainable model for leveraging technology in education that is adaptable to the varied needs of students with IDD. The project's success hinges on its ability to foster a collaborative ecosystem that enhances teaching methodologies and engages educators, thereby ensuring that students with IDD can fully participate in and benefit from the advancements in STEAM education.

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