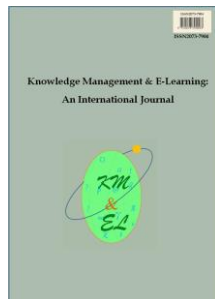

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Social entrepreneurship: Design and implementation of personalized 3D objects to enhance the autonomy of visually impaired people

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Abstract: This study analysed how the use of sensorised 3D models and advanced technologies can promote accessible and inclusive environments for visually impaired people. It also explored the potential of service-learning and the development of soft skills for future early childhood and primary school teachers. The research sample consisted of 14 people with visual impairment and 18 university students majoring in early childhood education and primary education. The materials selected included different 3D model designs and interactive tools such as Scratch® and makey-makey®. The visually impaired participants evaluated the models through touch and the students guided this process. The students were previously trained in digital competences, 3D design, entrepreneurship and the development of soft skills. Data collection was carried out through questionnaires. The results show a high level of satisfaction among visually impaired people in understanding objects through 3D models and an increase in teamwork and empathy among university students. It is concluded that the use of advanced digital technologies significantly improves the quality of life and social inclusion of visually impaired people. Likewise, service-learning enhances technical, social, and entrepreneurial skills of future teachers.

Keywords: Visual impairment; Inclusive technologies; Service-learning; Soft skills; Digital entrepreneurship

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1. Introduction

People with visual impairment face a physical and social environment that significantly limits their mobility and autonomy due to orientation difficulties (Davis & Chansiri, 2019; Maher et al., 2024). Given that one of the most dramatic consequences of the limiting conditions caused by visual impairment is loss of mobility (Ricci et al., 2023), it is essential to train them in mobility skills and provide them with efficient and safe accessibility resources to ensure their autonomy in any context (Niu et al., 2017).

In addition to having to detect objects in the environment, they need additional information about their location in space. For this reason, the use of devices that emit an audio signal is of great help to them (Devi & Subalalitha, 2022). Also, 3D printing as well as other text-to-speech applications have been shown to facilitate social inclusion in various environments for people with visual impairment (Yang et al., 2022). On the other hand, the combination of 3D resources with electronic sensors has shown progress in facilitating mobility for these people (Rizzo et al., 2017). In addition, assistive technologies such as text-to-speech software, navigation/spatial guides, and object recognition tools have proven to be effective and positive in improving the quality of life of people with blindness and low vision (Liu et al., 2024). Furthermore, the advancement of new technologies, such as 3D printing and visualization, has increased interest due to their great potential to facilitate object perception through haptic sense, helping people with visual impairment to access tactile experiences that enable them to better understand their environment (Gyoshev & Ka-rastoyanov, 2018; Hakobyan et al., 2013).

People with visual impairment face various psychosocial barriers, which negatively impact their quality of life by limiting their employment opportunities (Seth et al., 2023). In response to this issue, the development of innovative technological tools, such as virtual reality platforms (Vergara et al., 2017), have shown great potential to improve mobility skills and foster independence (Ricci et al., 2023). An example of such technological solutions are advanced tools that, by means of a pocket-sized 3D printed smartphone accessory and well-established machine vision algorithms, generate audio instructions that guide the user through the different fields to complete a form (Feiz et al., 2019).

In addition, the ageing of the population, together with other factors, has led to an increase in the prevalence of visual impairment worldwide. According to WHO estimates, by 2050, more than 60 million people are expected to be blind and more than 400 million are expected to be visually impaired (Han et al., 2024). This affects more than 450 million people around the world, placing a considerable burden on public health and economic systems (Li et al., 2020). However, technological advances have made it possible to significantly improve the living conditions of people with visual impairment (Miele, 2017).

The inclusion of the aforementioned group in the social context requires a multidimensional approach that goes beyond the creation of materials based on technological development. Martiniello & Wittich (2024) point out the importance of

promoting awareness-raising initiatives that address this issue as a social and civic need. This is a task that could be undertaken by university students in the field of education and future teachers, which would entail implicit training in soft skills. This would contribute positively to the development of their professional skills linked not only to the creation of digital content and ICT integration (Tomczyk, 2024). Specific training for students would also be necessary in order to promote educational inclusion and attention to diversity (Ancaya-Martínez et al., 2024). Finally, this multidimensional approach encourages the development of entrepreneurial skills aimed at generating creative and innovative proposals with a social purpose (Peña Hita et al., 2023).

The relevance of soft skills as a determinant for personal and professional success is now widely recognized (Folomieieva et al., 2024; Ngo, 2024). However, deficiencies in teachers' digital and soft skills have been identified. This underlines the need to address these gaps within a structured competence framework, which provides a tailored response (Romo et al., 2024). University education must face the challenge of providing quality training for future teachers, with real implications for their professional development, enhancing teamwork, communication and the development of critical thinking skills (Hains-Wesson & le Roux, 2024).

The ability to respond to social expectations and needs requires skills such as self-confidence, decision-making, leadership, creativity, empathy, value acquisition, assertive communication and personal initiative (Albán & Benítez, 2024), as well as the assumption of responsibilities and the quality of self-management (Varshavskaya, 2024). Therefore, future education professionals should not only possess technical competences, but also develop strong communication and negotiation skills, which should be fostered in the university environment (Marchenko et al., 2024). Soft skills are acquiring a clearly defined status in higher education, ensuring the formation of key competences in students (Rozhnova et al., 2024). The so-called University 4.0 should provide intelligent, digital training and sensitive development of soft skills in future teachers (Rosak-Szyrocka, 2024).

Likewise, digital entrepreneurship has established itself as a necessary competence in the contemporary professional landscape, demanding innovative pedagogical strategies in Higher Education and better preparation of teachers (Irfan & Malik, 2023; Thanasi-Boçe & Kurtishi-Kastrati, 2024; Vergara et al., 2024). While entrepreneurial activity has a long historical history, the digital age in recent years has greatly influenced its nature and impact (Allen et al., 2019). Consequently, there is a growing commitment to fostering science and technology-based entrepreneurship, with the aim of contributing to social and economic development (Antón-Sancho et al., 2024; Bolzani et al., 2021).

University institutions are implementing proposals to develop new forms and processes of academic entrepreneurship (Fayolle et al., 2021), which are conditioned by digital technologies (Rippa & Secundo, 2019) and social impact (Calderón-Martínez & Peláez-Higuera, 2024). Recent studies have corroborated that participation in entrepreneurship and digital entrepreneurship courses have a strong impact on the development of entrepreneurial competence in STEM students (Çoban et al., 2022; Pergelova et al., 2023; Primario et al., 2022). To enhance the progress of digital entrepreneurship, the confluence of three factors is key (Fig.1.): (i) a strong motivation towards the adoption of digital technologies; (ii) a strong interest in the realization of academic entrepreneurship; and (iii) the presence of innovative models of entrepreneurship in academia (Muafi et al., 2021).

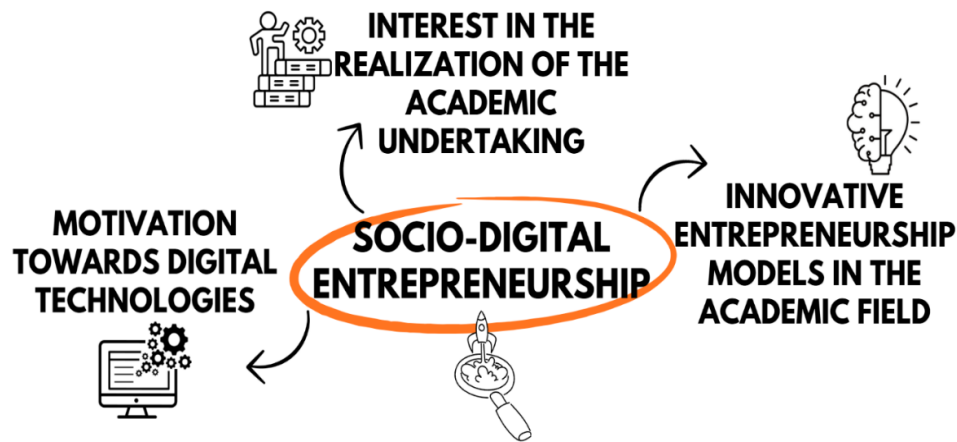


Fig. 1. Key factors to foster socio-digital entrepreneurship

The main objective of this research is to design a multidisciplinary intervention that, through the combination of innovative digital technologies and practices of the service-learning methodology, contributes to improving the quality of life of visually impaired people. The creation of personalized 3D materials, manufactured with 3D printing technologies and equipped with electronic sensors, will facilitate the accessibility and inclusion of these people in different areas of daily life. It also seeks to promote the participation of university students in community service projects, thus fostering the development of professional and social skills aligned with the principles of inclusion and diversity.

2. Method

2.1. Participants

The study population consisted of two groups of people. The first group consisted of 14 visually impaired individuals: 10 men and 4 women affiliated to the Spanish National Organization of the Blind (ONCE) in the province of Ávila (Spain), aged between 65 and 85. The second group consisted of 18 university students of the Degree in Primary Education and Early Childhood Education of the Catholic University of Avila (UCAV), 9 men and 9 women between the ages of 18 and 24. The university students participated in the research according to two premises. Firstly, they received specific training in different areas: (i) development of entrepreneurial competences and soft skills; (ii) programming contents with Scratch®; and (iii) principles of 3D printing design and development of interactivity with the interactive creation kit makey-makey®. Secondly, the service-learning session took place (see Fig. 2b and Fig. 2c), which consisted of a structured interaction in which trainee teachers guided participants with visual impairments in exploring the sensorised 3D models (see Fig. 2a) through haptic perception. Each participant received individualised attention: the teachers verbally described the purpose and functionality of the object, while the participants tactily examined the textures, shapes, and interactive elements. Any questions or requests for clarification from blind participants were addressed immediately through guided explanations, which encouraged

two-way communication and ensured systematic observation of perception and recognition abilities through the haptic channel.



Fig. 2. a) designed 3D materials; b) theoretical service-learning session between visually impaired people and university students; c) practical service-learning session between visually impaired people and university students

2.2. Instruments

For data collection in the present research (see Fig. 3), three questionnaires were used as research instruments. In each of these questionnaires, different research variables have been analyzed according to each group of participants. The first questionnaire, aimed at visually impaired people, is made up of 5 questions to be answered on a Likert scale from 1 to 5 (1 being the lowest and 5 the highest), in which different variables oriented towards the usefulness and effectiveness of the sensorised 3D models were analyzed (see Table 1): Q1-1: understanding of objects; Q1-2: texture providing additional information; Q1-3: improved accessibility; Q1-4 comfort in using mock-ups; and Q1-5: identification of object details.

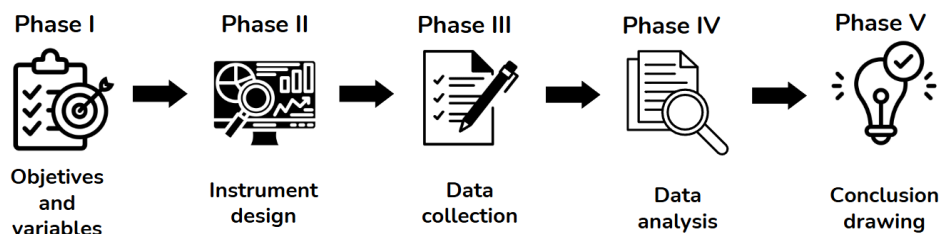


Fig. 3. Method

The second questionnaire, aimed at university students, is made up of 8 questions, in which different polytomous variables related to the development of soft skills and the overall assessment of the project were analyzed (see Table 2): Q2-1: the overall assessment of the project; Q2-2: the usefulness; Q2-3: the learning opportunity; Q2-4: the promotion of awareness and empathy; Q2-5: teamwork; Q2-6: motivation towards new projects; Q2-7: the reaction of visually impaired people to receiving the product; Q2-8: the degree of experience of delivering the product to people with disabilities, all essential in the development of their training as future teachers.

Table 1

First questionnaire: effectiveness of sensorised 3D models

Variable	Description	Responses
Q1-1	Rate to what degree you felt that the 3D models helped you to better understand the objects represented	Likert scale from 1 to 5 (1: Not at all; 2: Low; 3: Moderate; 4: High; 5: Very high)
Q1-2	Rate the degree to which the textures of the models provided you with additional information about the objects	
Q1-3	To what extent do you think 3D models could improve accessibility in cultural environments?	
Q1-4	To what degree did you feel comfortable using the 3D models during the research?	
Q1-5	Rate the degree to which you found it easy to identify the details of the objects through the 3D models	

Table 2

Second questionnaire: Soft skills development and project assessment

Variable	Description	Responses
Q2-1	Quantify your overall assessment of this project	Likert scale from 1 to 5 (1: Not at all; 2: Low; 3: Moderate; 4: High; 5: Very high)
Q2-2	Assess the practical usefulness of the project	
Q2-3	Value the learning opportunity	
Q2-4	Value the promotion of awareness and empathy	
Q2-5	Value the promotion of collaboration and teamwork	
Q2-6	After this experience, assess your motivation for new projects that have a positive social impact	
Q2-7	Please rate how seeing the reaction of visually impaired people to receiving the product inspired you to think more innovatively about solutions to social problems	
Q2-8	To what degree do you consider that the experience of delivering the product to visually impaired people was valuable for your personal and professional development?	

Finally, the third questionnaire, also aimed at university students, has 8 questions, to be answered on a Likert scale from 1 to 5 (1 being the lowest and 5 the highest), in which different variables have been analyzed, oriented towards entrepreneurial skills (see Table 3): (i) Q3-1 the degree of entrepreneurship; Q3-2: the motivation to look for new trends; Q3-3: the willingness to delve into complex problems to find innovative solutions; Q3-4: the willingness to explore new approaches; Q3-5: the enthusiasm for the idea of leadership; and Q3-6: the collaboration and search for teamwork opportunities.

2.3. Procedure

The work was conducted in accordance with the ethical principles of the Helsinki Declaration (Cantín, 2014), so the privacy and anonymity of the participants was guaranteed. As part of the research, an information session was held for the study participants (students and people with visual impairment). During this session, detailed information about the functioning of the models and the research procedures was provided.

This research was carried out in five phases (see Fig. 3): (i) determination, definition and formulation of the research objectives and variables, as well as the inclusion

criteria of the target population; (ii) design of the questionnaires used as research instruments; (iii) data collection from the responses to the questionnaires sent to the target population; (iv) analysis of the data obtained; and (v) drawing and formulation of conclusions.

Table 3

Third questionnaire: Assessment of entrepreneurial skills

Variable	Description	Responses
Q3-1	How entrepreneurial do you consider yourself?	
Q3-2	I am motivated to actively seek and explore new trends and markets to identify business or improvement opportunities	Likert scale from 1 to 5 (1: Not at all; 2: Low; 3: Moderate; 4: High; 5: Very high)
Q3-3	I am willing to research and delve into complex problems in my environment to find innovative solutions	
Q3-4	I consider myself open to exploring novel approaches and creative solutions when faced with challenges	
Q3-5	I am excited about the idea of leading and inspiring others towards a common vision or project	
Q3-6	I value collaboration and actively seek out opportunities to work as part of a team	

2.4. Data analysis

Following data collection (Phase III, Fig. 3), descriptive statistical analysis was used. The descriptive statistical analysis in SPSS version 29.0.1.0 allows us to analyze the main characteristics of the data set obtained using specific procedures according to the type of variable. In the case of numerical variables, the descriptive statistical analysis allows us to analyze the central tendency through the mean statistic ($\bar{X}$), as well as the dispersion of the data with the standard deviation statistic (σ) and the relative variability of the data through the coefficient of variation statistic (CV). Non-parametric tests have also been carried out to study which variables have significant differences in their responses by calculating the p-value with a significance value of 0.05.

3. Results

The results obtained from the application of the questionnaires to visually impaired people show, as shown in Table 4, a high degree of satisfaction in various aspects. In particular, the participants expressed a positive evaluation with regard to the understanding of the 3D sensorised materials (Q1-1) and with regard to their texture, which provides them with additional information (Q1-2). Improved accessibility (Q1-3), ease of use of the models (Q1-4) and object identification (Q1-5) were also identified. The low values of standard deviation and coefficient of variation obtained in the responses indicate a high homogeneity in the ratings, with an average significantly above 4.

As for the students, their answers to the second questionnaire, presented in Table 5, reveal a high degree of satisfaction in the group with regard to the project (Q2-1), highlighting its practical character (Q2-2), the learning opportunity (Q2-3) and its contribution to the development of values such as social awareness, empathy (Q2-4), solidity, social responsibility, awareness of diversity and inclusion and teamwork (Q2-5) and a high degree of motivation towards new projects (Q2-6). They recognize that the

reaction of visually impaired people to receiving the product has inspired them to a great extent to propose innovative answers applied to the solution of social problems (Q2-7) and a high degree to the experience (Q2-8). The low values of standard deviation and coefficient of variation obtained in the responses of both groups indicate a high degree of homogeneity in the evaluations, with an average significantly higher than 4.

Table 4

Mean ($\bar{X}$), standard deviation (σ) and coefficient of variation ($\sigma/\bar{X}$) of the first questionnaire

Variable	$\bar{X}$	σ	$\sigma/\bar{X}$
Q1-1	4.25	.75	.17
Q1-2	4.42	.79	.18
Q1-3	4.42	.90	.20
Q1-4	4.17	.58	.32
Q1-5	4.83	.39	.08

Table 5

Mean ($\bar{X}$), standard deviation (σ) and coefficient of variation ($\sigma/\bar{X}$) of the second questionnaire

Variable	$\bar{X}$	σ	$\sigma/\bar{X}$
Q2-1	4.92	.28	.06
Q2-2	4.92	.28	.06
Q2-3	4.77	.44	.09
Q2-4	4.92	.28	.06
Q2-5	4.85	.38	.08
Q2-6	4.62	.51	.11
Q2-7	4.92	.28	.06
Q2-8	4.85	.38	.08

The students' responses to the third questionnaire are reflected in Table 6 and show a high level of satisfaction with respect to the different aspects evaluated with averages close to 4. These results show the high degree that students have shown in their entrepreneurial spirit (Q3-1), motivation towards new trends (Q3-2), openness towards researching complex problems (Q3-3), exploration of new approaches (Q3-4), enthusiasm for leading and inspiring others (Q3-5) and the high importance of collaboration and seeking opportunities for teamwork (Q3-6). Students, in the case of motivation to seek and explore new trends and markets (Q3-2) and enthusiasm for the idea of leading (Q3-5), scored less than 4 on average.

Table 6

Mean ($\bar{X}$), standard deviation (σ) and coefficient of variation ($\sigma/\bar{X}$) of the third questionnaire

Variable	$\bar{X}$	σ	$\sigma/\bar{X}$
Q3-1	4.06	.94	.23
Q3-2	3.78	1.00	.26
Q3-3	4.11	.68	.17
Q3-4	4.17	.86	.21
Q3-5	3.83	.78	.20
Q3-6	4.00	.49	.12

4. Discussion

Once the results were obtained, they were analyzed (see Fig. 3), identifying in the three questionnaires which variables differed significantly from the rest. In the case of the first questionnaire aimed at people with disabilities, the results obtained indicate significant differences in the perception of the participants with respect to certain aspects evaluated. Firstly, the chi-square tests applied to the questions on the understanding of the objects represented by 3D models (Q1-1) and the additional information provided by the textures (Q1-2), yield significance values greater than .05, so there are no significant differences in the distribution of responses. However, with regard to the perception of improved accessibility in cultural environments (Q1-3), comfort in using 3D models (Q1-4) and ease of identifying details through 3D models (Q1-5), significance value of less than .05 are observed. These results indicate that there are significant differences for these variables, indicating that 3D mock-ups influence the user experience (Yang et al., 2022). For the variable Q1-4, the analysis was performed using the binomial test (see Table 7).

Table 7

Significance values of the first questionnaire

Variable	Test	<i>p</i>
Q1-1	Chi-square	.47
Q1-2	Chi-square	.17
Q1-3	Chi-square	< .05
Q1-4	Chi-square	< .05
Q1-5	Binomial	< .05

In the case of the second questionnaire addressed to the group of university students, the results also show significant differences in the perception of the participants with respect to several aspects evaluated. The binomial test was used to calculate which variables had significant differences in their responses. In the case of the overall assessment of the project (Q2-1), the assessment of the practical usefulness of the product for people with visual impairment (Q2-2), the assessment of the awareness and empathy towards their needs (Q2-4), the assessment of the reaction of people with visual impairment on receiving the product to inspire them to think more innovatively about solutions to social problems (Q2-7) and the assessment of the degree to which the product is delivered to people with visual impairment for personal and professional development (Q2-8) have significance values of less than 0.05, indicating that there are significant differences between the results of the project and those of the participants. .05, indicating that there are significant differences in responses (see Table 8). These results support other previously mentioned studies that promote the use of innovative methodologies to promote accessibility (Gyoshev & Karastoyanov, 2018), fostering awareness and empathy towards people with visual impairment (Hakobyan et al., 2013).

In the third questionnaire addressed to the group of university students, the results of the statistical tests also reflect diverse perceptions regarding participants' skills and attitudes towards entrepreneurship and collaboration (Hita et al., 2023; Miele, 2017). In this case, the chi-square test was used to obtain the variables with significant responses. In relation to the self-assessed level of entrepreneurship (Q3-1), the level of exploration towards novel approaches and creative solutions (Q3-4), the level of enthusiasm to lead and inspire others towards a common vision or project (Q3-5) and the level of valuing collaboration and opportunities for teamwork (Q3-6), the significance value is less than

0.05, indicating that there are significant differences in the participants' responses (see Table 9).

Table 8
Significance values of the second questionnaire

Variable	Test	<i>p</i>
Q2-1	Binomial	< .05
Q2-2	Binomial	< .05
Q2-3	Binomial	.09
Q2-4	Binomial	< .05
Q2-5	Binomial	.02
Q2-6	Binomial	.58
Q2-7	Binomial	< .05
Q2-8	Binomial	< .05

Table 9
Significance values of the third questionnaire

Variable	Test	<i>p</i>
Q3-1	Chi-square	< .05
Q3-2	Chi-square	.57
Q3-3	Chi-square	.12
Q3-4	Chi-square	< .05
Q3-5	Chi-square	< .05
Q3-6	Chi-square	< .05

The analysis of the results obtained from the three questionnaires (see Fig. 3) indicates that there are differences in the perception of the participants with respect to various aspects evaluated, both in the visually impaired people and in the group of university students and the analyzed variables.

In the first questionnaire, addressed to visually impaired people, it has been observed that there are no significant differences in the perception of the comprehension of objects represented by 3D models (Q1-1) and the additional information provided by textures (Q1-2), which suggests that these variables have been assessed homogeneously among the respondents.

In the second questionnaire, addressed to students, aspects such as learning opportunity (Q2-3) and motivation towards new projects (Q2-6) did not show significant differences in the answers, which could reflect a uniform perception of the great learning opportunity and future projection.

Finally, in the third questionnaire, also addressed to the group of university students, the variables such as motivation to seek and explore new trends (Q3-2) and willingness to investigate and delve into complex problems (Q3-3) did not show significant differences, which could indicate the need to reinforce strategies to motivate and foster a more analytical and proactive mentality in this group (Bermeo-Giraldo et al., 2022).

When analyzing the three questionnaires together, there is a clear relationship between the perception of the impact of the project in the two groups of participants, since the results of the first questionnaire show that the direct beneficiaries (people with visual

impairment) significantly value the accessibility, comfort and ease of use, highlighting the importance of training in skills for their movement and autonomy in any context (Niu et al., 2017), which is aligned with the perceptions of the students in the second questionnaire, who recognize the practical usefulness of the product and the positive social impact it generates in its recipients due to the promotion of awareness and empathy, the reaction of visually impaired people and the great experience for their personal and professional development. This contributes positively to the development of their professional skills linked to the promotion of educational inclusion and attention to the diversity of their students (Tomczyk, 2024). In addition, this approach fosters the development of entrepreneurial skills aimed at generating creative and innovative proposals with a social purpose (Primario et al., 2022). The positive feedback from visually impaired people seems to have directly influenced students' motivation to think of innovative solutions, showing a connection between practical experience and the perception of social impact (Yang et al., 2022).

The second questionnaire reflects how participation in the project has impacted on students' social awareness and empathy, and the third questionnaire highlights its influence on the development of entrepreneurial and leadership skills, as well as teamwork. This suggests that the project has not only generated a positive social impact but has also contributed to the personal and professional growth of the participants (see Fig. 4).

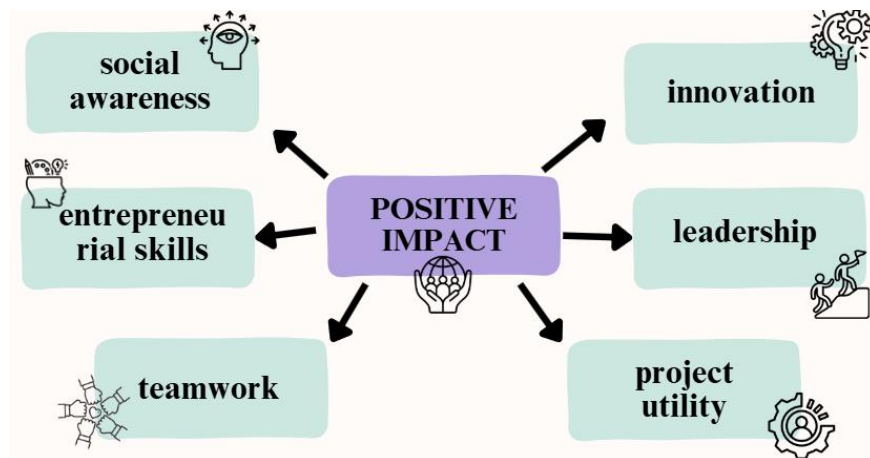


Fig. 4. Most significant results of this research

In both the first and third questionnaires, the results reveal a strong relationship between visually impaired people's perception of accessibility, the comfort of 3D models and the degree of identification of details, and the development of entrepreneurial and collaborative skills in university students, such as the influence on students' self-assessment of their level of entrepreneurship and their willingness to explore creative and innovative solutions (Rozhnova et al., 2024). In addition, user satisfaction with the models has reinforced students' motivation to take on leadership roles and highlighted the importance of collaboration and teamwork in the search for inclusive solutions.

Therefore, the results of the three questionnaires show that the project experience has had a positive impact on both visually impaired people and university students, strengthening their social awareness, entrepreneurial skills and teamwork abilities (Thanasi-Boçe & Kurtishi-Kastrati, 2024). The positive perception of the accessibility and

ease of use of the 3D models has reinforced the students' appreciation of the usefulness of the project, which in turn has boosted their enthusiasm for leadership and innovation (see Fig. 4).

5. Conclusion

The creation of personalized 3D materials, manufactured with 3D printing technologies and equipped with electronic sensors, allows better access and greater inclusion of visually impaired people. Furthermore, throughout the implementation of the project, no significant difficulties were identified for either visually impaired participants or trainee teachers. When blind participants expressed doubts about specific elements of the 3D models, the trainee teachers provided the necessary explanations and clarifications, which helped to maintain smooth interaction and reinforced their role as mediators of accessible learning experiences.

The results obtained in the present research, after analysing three questionnaires, indicate that the project has had a significant impact on both university students of the Bachelor's Degrees in Education and visually impaired people. A very positive assessment has been made of the accessibility and ease of use of the 3D models by visually impaired participants. In addition, the students highlighted the practical use of the models and appreciated their influence on the development of certain entrepreneurial skills, influencing their social awareness and leadership. The application of service-learning pedagogy in the university environment facilitates the combination of academic content work with the development of a sense of community. All of this promotes social entrepreneurship, which strengthens the integral formation of the students.

This work shows how the development of certain projects that favour experiential learning, linked to social innovation initiatives, contribute to promoting professional development and generate civic awareness in their participants. Despite this, and as an aspect for improvement, further research is recommended to ensure that the usefulness and practicality of the 3D materials generated are adapted to the needs of the visually impaired and facilitate their integral development and social inclusion.

Author Statement

The authors declare that there is no conflict of interest.

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