The Influence of Technology-Based Pedagogy in Vocational Education on the Motivation and Emotional State of Students with Hearing Impairments

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Starting from the need to find the most appropriate methods of teaching information from the STEM area to children with special needs, this article aims to investigate how technology-based pedagogies influence the motivation and emotional state of students with special needs when they have to assimilate knowledge in this field. The research data demonstrated an increase in the motivation for learning of these students through the use of ICT, but also an improvement in the affective state through the increase in self-confidence. These improvements were possible due to the fact that the students could go through each stage of the lesson at their own pace, with the possibility to return to those more difficult aspects.
Keywords: *Inclusion, Technology-based pedagogy, Special Educational Needs, Vocational education, Hearing impairment*
DOI: 10.24818/issn14531305/28.3.2024.02

1 Introduction

The study presented in this article is grounded in a dual focus that correlates, first, the ongoing commitment to delivering quality education to all students, including those with typical development and those from vulnerable groups, and, second, the persistent decline in students' interest in STEM subjects. The study is based on the work of two European projects: NEWTON, a Horizon 2020 project and GIVE, an Erasmus + project. These two projects focused on identifying the most useful ways to convey science information to all students, including those from vulnerable groups, so as to generate adequate level of motivation for learning.

Functional diversity and inclusion opportunities can be addressed through using a diversity of digital tools in education (Alper and Goggin, 2017; Meyer, Rose, & Gordon, 2014). The simultaneous use of traditional and modern methods, based on computer technologies in education and training, has proven a high level of efficiency (Graham et al., 2013; Clark & Mayer, 2016; OECD, 2016).

In the context of the GIVE project, based on the analysis of the main characteristics, six categories of students belonging to vulnerable groups were grouped into two clusters:

- The first cluster includes students with disabilities, special educational needs and low skilled. In this cluster, vulnerability is related to a number of individual / internal factors
- The second cluster includes a group of students with migration background, students with drop-out history and students with difficult socioeconomic background. As we can see, in this cluster vulnerability is related dominantly to environmental factors or social factors.

Analyzing the psychological and developmental elements specific to the vulnerable groups targeted in these projects, we identified two categories of features: features that are common to all three vulnerable groups which form a cluster, features that are common to both clusters (all vulnerable groups).

In the first cluster in which vulnerability is caused by internal, individual factors, we identified three common characteristics

- Difficulties in information processing – that can occur at any of the following levels: information collection and representation, retention, but especially understanding the information
- More or less accentuated delays in the areas of communication, cognition, emotional maturity, skills development
- More or less accentuated inequalities in their own development with the presence of a high potential in some areas, associated with difficulties in other ones.

Common characteristics of vulnerable groups from second cluster, in which vulnerability is caused by external factors are:

- Social emotional difficulties that manifest through difficulties in emotional self-regulation, social awareness and social involvement, all with a negative effect on adaptation
- Low sense of belonging, which is associated with a decrease of the feeling of being connected with a social, cultural or professional group, with implications on the level of involvement and attachment that an individual has to the community.
- Low life satisfaction - low self-perceived ability to cope with everyday life, low self-esteem, difficulty in achieving goals.

In addition to these common characteristics for each category of vulnerable groups, we were able to identify three common cross-sectional characteristics for all six groups analyzed:

- Limitations in communication process that can occur at encoding, transmitting, and decoding information. These difficulties can be caused either by language barriers or by difficulties in receiving and processing information.
- Low level of shown learning motivation ow interest in learning, low self-confidence, anxiety caused by repeated failures, negative attitudes.
- Difficulties in school and social inclusion - inability / reduced ability to fully participate in school life as well as in the economic, social, political and cultural life.

Based on these characteristics of students from vulnerable groups and analyzing the specialized literature, a series of innovative pedagogies were identified that can meet the educational needs of these students with the aim of ensuring equal opportunities in education (Figure 1) (https://www.thegiveproject.eu/wp-content/uploads/2023/04/D.2.6.b.pdf)

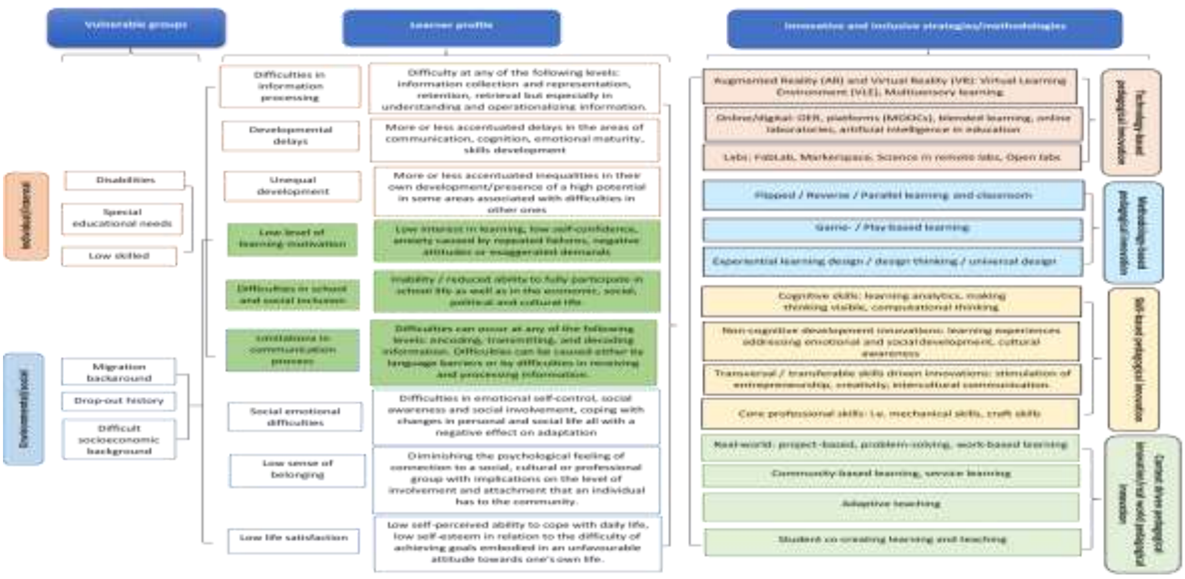

Fig. 1. Inclusive innovative pedagogies for vulnerable groups

This study seeks to assess how innovative, technology-based pedagogies can impact the learning motivation and emotional well-being of children whose vulnerability is shaped by the presence of a hearing disability during school activities.

2 Related works

Digital and technical skills of children/students with disabilities

The technologization of the educational process in special and inclusive education, both through gadgets and personalized support applications for each type and degree of disability, as well as at the level of didactic strategies and stages of the educational process, demands the existence of general skills in the use of ICT. The main positive effects of the use of ICT by students with disabilities relate to: accessibility through online courses and study at home, respecting one's own work rhythm, with the possibility of participating together with colleagues in the common program, progress in communication with the teaching staff and colleagues, increasing independence in learning, reducing stress, higher perceived self-efficacy, transposing teaching materials into alternative formats, corresponding to special learning needs (Black, Weinberg, & Brodwin, 2015; Dell, Newton, & Petroff, 2017; Kelly & Smith, 2011; Wu et al., 2014). All these benefits become impossible to access due to the barrier of access to technology, multiple studies demonstrating differences regarding accessibility by reference to the type of disability, gender, nationality, family structure, residential environment, etc. (Cruz-Jesus et al, 2016), which led to the emergence of the concept of the digital divide. It refers not only to the presence of digital devices and materials, but also to the existence of digital skills and competencies. Analyzing the differences regarding the digital skills of general school students with specific learning disorders and without disabilities, Wu et al. (2014) identify differences regarding ICT skills and emphasize that access to technology does not facilitate the emergence of skills, in the absence of specific training programs.

The interest of specialists in quality curriculum adaptation and technology-based didactic design in special education has been constant in recent years (Crow, 2008; Seale, 2013; Pădure, 2020). The perceptions of children/students with disabilities regarding their own technical skills and didactic activities involving the use of digital technology were explored through specialized studies that included students with mild disabilities at high school and university levels. Fichen et al. (2009) identified limits (reported by 223 pupils and students with disabilities participating in the study) regarding: accessing websites and platforms on which courses/learning take place, logging into activities synchronously, accessing digital video content and audio (downloading and opening files), time management during online exams, following the presentation of course materials in PowerPoint, PDF or other formats during teaching, the absence of adaptive technology, the perception of a low level of own digital skills. The perceived level of digital skills among students with disabilities was found to be medium and low in the directions (which guided the study) – technological literacy, the ability to search for information, critical thinking, problem solving, technologically mediated communication and collaboration (Cabero-Almenara et al. 2022). The same authors, in a study carried out in 2023, highlight the fact that a predictor of quality digital educational assistance for students with special educational needs is represented by the digital skills of teachers (which proved to be of medium and low level on a batch of 1194 teachers from Andalusia). The involvement of teachers in the development of their own digital skills proved to be mediated by the gender of teachers, the attitude towards the use of ICT in teaching, the presence of students with special educational requirements in the classes they teach, resulting in the need for support for teacher training in the sphere of adaptation and selection of digital didactic resources.

Gamification and game-based learning

The terminology related to the use of digital games in education involves a number of concepts with specific dimensions, characteristics and practical utility. Thus, gamification is defined as the process by which criteria, notions and components of digital games are transposed into various contexts, serving purposes that may or may not completely exclude the playful element (Fleming et al., 2017). Gamification in education refers to a concept, an orientation, a theory, a project, etc. approached through game elements, around which the actual teaching-learning process is structured. It is also characterized by student-centered learning and assessment based on reward and reinforcement systems (Becker, 2021).

The most common purposes are training, motivation, behavioral and cognitive change. The applicability of these types of games goes beyond the educational sphere, looking at health, social justice, politics, entrepreneurship, etc. (Becker, 2021, Fleming et al., 2017). Digital Game Based Learning is the learning of content, practical knowledge and attitudes, translated into behaviors through the intentional use of digital games. This constitutes the transposition of the digital game in an educational context, while the pedagogy based on the digital game (Digital game pedagogy) concerns teaching based on the particularities and constituents of digital games. The two concepts involve two interconnected facets, looking at both the student and the teacher - "learning from digital games, respectively teaching with digital games" (Becker, 2021, p. 3).

Recently, the topic of gamification in education in general and, in particular, in the education of children with disabilities, has caught the attention of specialists, resulting in meta-analytic studies that allow comparisons and records of the effectiveness of digital games in recuperative interventions. In intellectual disabilities and autism, the functional limitations at the cognitive level and adaptive behavior, addressed through gamification (serious games) have been overcome by the positive effects in socialization and communication in the case of autism spectrum disorders, respectively in cognitive development in intellectual disabilities (Tsikinas & Xinogalos, 2018). Papanastasiou et al. (2017) in a meta-analysis of studies published between 2007 and 2017 on the topic of using digital games in special education, highlight the advantages for students with attention deficits, memory deficits and with a diagnosis of developmental disorders, not only regarding increasing involvement in educational tasks, but also regarding the perception of success, increasing self-esteem and autonomy, so desired in special education, improving communication in learning activities and expressing creativity.

In the professional training of people with developmental disorders, the use of video games facilitates the transition from the learning experience to the real world, to the actual performance of the tasks, demonstrating the acquired skills, especially since, in the case of people with disabilities, the practical application of some concepts is problematic (Kwon & Lee, 2016). Other advantages include: acquiring skills required at work, the possibility of rehearsals; allows independence and commitment in learning, facilitates problem solving; fast feedback on both success and failure in the task, harder to provide and accept in traditional learning. Also, the authors do not exclude a series of risks, especially social risks. Therefore, digital games allow individualized practice, in the sufficient number of repetitions before the actual performance of specific learning behaviors. Digital games increase perceived self-efficacy in performing specific work tasks. They cost less than most vocational counseling and training services for people with disabilities, tasks are performed with greater precision and, after repetition, with greater speed.

Augmented reality and virtual reality in inclusive education

Augmented reality differs from virtual reality by its property of allowing the user to visualize the real world in which 3D virtual objects have been included, superimposed, and they coexist in real time (Azuma, 1997; Carmigniani & Furht, 2011). So, computer interfaces, specific graphics, multimedia technology combine processed digital images with the perception of the real world ensuring more efficient interaction with it and its deeper understanding (Amin & Govilkar, 2015). In virtual reality, the user benefits from an interactive, three-dimensional experience, but contact with the real environment is no longer possible. Augmented reality is a form of virtual reality (Wu et al., 2013) in which the virtual manipulation of objects becomes possible, with important effects in the learning activity. In addition to the benefits that this type of technology brings to education, a series of limits regarding applicability in the field of special education are specified, among which are: the training of teaching staff regarding the design of lessons mediated by augmented reality, the lack of technologies involved and their high costs, technical problems and those related to accessing equipment by students with disabilities (Fernández-Batanero et al., 2022).

The role of augmented reality in addressing special educational needs was explored through a meta-analysis involving 18 studies indexed in the Scopus and Web of Science databases, published between 2016-2021 (Fernández-Batanero et al., 2022). The educational levels at which educational activities of this type were implemented were, in order of frequency of activities: primary school, with the highest frequency, followed by gymnasium, preschool, high school and university. From the point of view of disability, the most frequently studied were intellectual ones, followed by autism spectrum disorder, specific learning difficulties, and with the lowest frequency, hearing disabilities. Looking at the effects of using augmented reality on learning, the cited authors mention, in order of importance: academic performance, motivation and involvement in learning tasks, communication and social interaction in learning tasks, autonomy in learning. Other researchers (Cakir & Korkmaz, 2019) emphasize the effectiveness of didactic materials based on augmented reality, which they describe as useful, practical and appropriate, in reducing teacher dependence in solving learning tasks and enriching the learning experience by being close to real life. Also, students were more active, more enthusiastic and more willing to participate, which increased the correctness of solving learning tasks by referring to traditional teaching methods. Augmented reality led to positive results regarding all these categories of skills, the classification in order of importance being - learning skills, followed by social, physical and personal life management skills. To these are added the skills involved in ensuring personal autonomy, social skills and increasing confidence in physical abilities in general (Yenioglu et al., 2023).

Regarding virtual reality, Kavanagh et al. (2017) point out that, despite its proven effectiveness, large-scale implementation at the educational level is dependent on the limitations arising from the technologies involved, the lack of necessary equipment and facilities, high costs and user experience with this type of technology. Analyzing the perspective of educators in the design and implementation of activities with the support of virtual reality, it was identified as the main role of these activities in the intrinsic motivation of students, with the valorization of collaboration in learning.

Virtual Education Labs (FabLabs)

FabLabs are defined as small workshops equipped with computer-controlled tools and technologies, digital editing tools (e.g. 3D printers) where custom digital fabrication is carried out. The learning opportunities offered by FabLab cannot exclude the careful analysis of the needs of students, especially those with disabilities, didactic planning and supervision of students during implementation in order to safely carry out their activities (Love et al., 2020). In a quantitative and qualitative analysis of the specialized literature (45 selected studies), Soomro et al. (2022), looked at the role of virtual education laboratories in the cognitive development and creativity of students. The results indicated that this type of learning design supports the development of problem-solving skills, cooperation and creates the context for the expression of creativity, also improving communication. In the analyzed studies FabLabs are described as specific learning environments characterized by valuing and offering possibilities for experimentation, observation and social learning mediated by technology (Soomro et al., 2022). FabLabs learning is non-formal learning where children have the opportunity to create through digital technology (Kinnula et al., 2020). The development of technical skills of students with disabilities and from disadvantaged social groups through FabLabs is also demonstrated by other studies (Lorenzo and Lorenzo, 2019), along with the promotion of diversity and equality. Students with learning disorders, intellectual disabilities and from disadvantaged categories, from families with low socio-economic status, participated in this study. They reported that they felt truly included in the group of students due to the increased performance in completing the tasks.

Using Artificial Intelligence (AI) in Vocational Education

AI offers a number of widely recognized benefits in education like personalized learning, increased user engagement and advanced learning analytics. They also apply to vocational education which has a much higher percentage of technical elements.

AI has been used in Romania efficiently in order to introduce lessons of educational robotics in school. According to Gheorghiu et al. (2023) using AI in education has enabled local Romanian teachers to implement attractive educational projects such as "building simple robots, plant caring robots, aeroponics towers, and robotic greenhouses is made possible by these learning tools for educators, children, and students"

The COVID-19 pandemic has boosted the use of AI in education. Online education has become common and socially accepted which has provided an opportunity for AI to enter into the classroom (Pantelimon et al., 2021). Teachers changed the way they work and many new technologies remained in schools after the pandemic period.

3 Research Methodology

Purpose of study: The current study aims to highlight the impact that technology-based pedagogies influence the motivation to learn STEM subjects and affective state in students with hearing disabilities attending a vocational school

Participants: In the study were 41 students included, with different degrees of hearing disabilities from the vocational school Sf. Maria Bucharest aged between 14 and 19 years old. The current study was based on the implementation of a set of lessons based on the use of ICT in the teaching of subjects from the STEM area. The set of lessons, called Earth Course, was developed within the NEWTON project and used AR, VR, game-based learning and FabLab technologies (Figure 2).

Piloting was carried out over a period of one month with a frequency of 3 lessons per week. The purpose of the lessons was to learn about the earth's atmosphere, chemistry, biology and physics using technology-based pedagogies.

Fig. 2. Technology-based lessons

Evaluation process:

The evaluation process included 3 stages (Table 1). The first stage was the pretesting one, applied before the implementation of the pilot, where the demographic questionnaires were applied to collect data on educational ability, attitude towards school, access to technologies, etc. and questionnaires related to learning motivation and affective state. The second stage involved the actual implementation of technology-based lessons (piloting) followed by the last stage in which motivation and affective state questionnaires were re-applied (re-testing).

Table 1. Stages in the evaluation process

Stage	Task
Before the pilot	Demographic questionnaire - Educational ability - Attitude towards school - Access to technologies.
	Learner motivation and affective state questionnaire (pre-pilot)
Pilot implementation	Implementing technology-based lessons
After the pilot	Learner motivation and affective state questionnaire (post-pilot)

The quantitative data collected through the questionnaires were supplemented with qualitative data obtained through the interviews and focus groups that took place at the end of each lesson.

Results

Analysis of the results obtained in the motivation for learning and affective state questionnaires were analyzed according to the educational abilities of the students based on the data collected through the demographic questionnaire. Thus, the students were divided into two groups:

- B1 - students with average and lower educational abilities;
- B2 - students with high educational abilities.

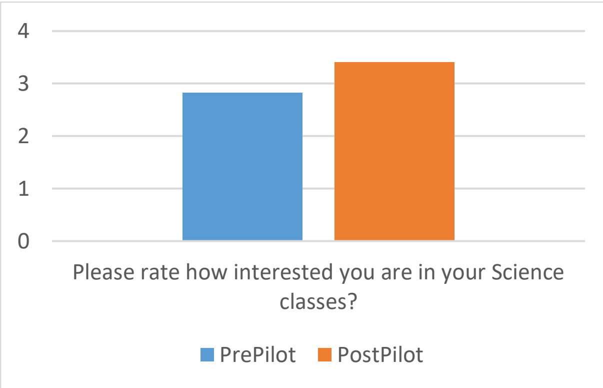

Fig. 3. Interest in Science classes – entire group of students

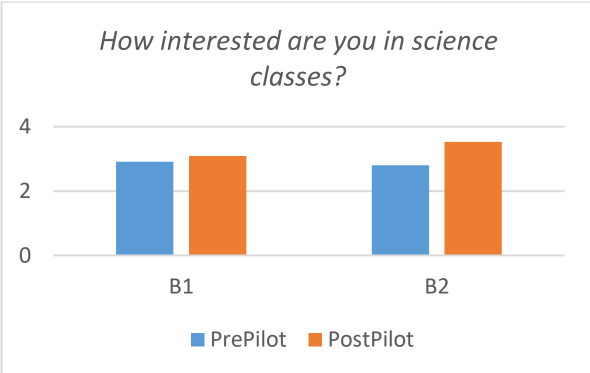

Fig. 4. Educational ability sub-groups – interest in sciences

Analysis of the results regarding the interest in learning for the entire group of students (Figure 3) showed an increase in students' interest in science classes after using NEWTON technologies. Majority of students reported that they felt more interested in science classes after using NEWTON technologies. Results of a paired t-test for means confirmed a statistical significant difference between the two questionnaires at $\alpha = 0.05$ ($t(41) = 3.423$, $p < 0.0001$).

Data analysis on the educational ability sub-groups (Figure 4) showed increases 6% and 23% in students' interest in science classes for groups B1 and B2 respectively after using NEWTON classes. Results of paired t-test for means confirmed a statistical significant difference between the results of the two evaluations at $\alpha = 0.05$ for group B2 ($t(30)=-3.61$, $p<0.001$).

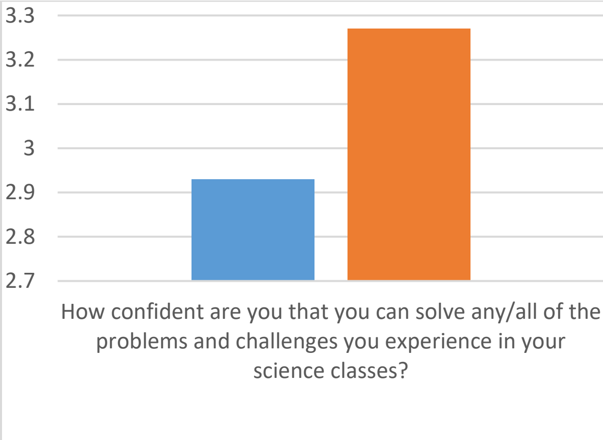

Fig. 5. Self-confidence – entire group

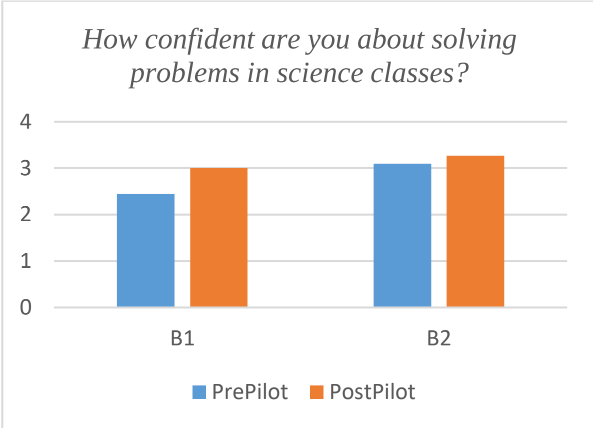

Fig. 6. Educational ability sub-groups – self-confident

Results relating to self-confidence in the entire group of students (figure 5) showed an increase in students' confidence regarding their ability to solve problems in science classes after using technology-based lessons. Despite all these differences, results of a paired t-test for means did not confirm a statistical significant difference between the two questionnaires at α = 0.05 (t(41) = 1.514, p=0.137).

Similar situations can be observed in the sub-groups of students based on their educational ability (Figure 6): results showed increases of 20.1% and 8.3% in students' confidence with respect to solving problems in science classes for groups B1 and B2 respectively after using technology-based classes. Results of a paired t-test for means did not confirm a statistical significant difference between the results of the two evaluations.

Tabel 2. Affective state – entire group of students

		t	**df**	**p**
Pair 1	While you were learning in your science class, to what extent did you feel engaged? Pre-post Pilot	-,194	40	,847
Pair 2	While you were learning in your science class, to what extent did you feel anxious? Pre-post Pilot	,961	40	,343
Pair 3	While you were learning in your science class, to what extent did you feel bored? Pre-post Pilot	1,107	40	,275
Pair 4	While you were learning in your science class, to what extent did you feel sad? Pre-post Pilot	1,157	40	,254
Pair 5	While you were learning in your science class, to what extent did you feel happy? Pre-post Pilot	-1,338	40	,188
Pair 6	While you were learning in your science class, to what extent did you feel enjoying it? Pre-post Pilot	-1,094	40	,281

Results showed increases in students' engagement, happiness and enjoyment respectively when learning using NEWTON Earth Course technologies (Table 2). Results of paired t-test for means show no statistical significant difference between the two questionnaires at p = 0.05 for all the variables mentioned above. Results also show declines in students' anxiety, boredom and sadness respectively when learning using NEWTON Earth Course technologies. Results of paired t-test for means showed no statistical significant difference

4. Discussions and Conclusions

Students with hearing disabilities face significant difficulties in processing information, especially verbal information. In

these conditions, their motivation for learning tends to decrease as they experience repeated failures. These not only decrease their motivation for learning, but also cause negative affective states to appear during the lessons and, at the same time, a low confidence in their ability to solve problems.
The data analyzed above demonstrate that the use of ICT in STEM lessons for children with hearing impairment allowed an increase in the motivation for learning, along with an increase in self-confidence, even if no significant progress was recorded in terms of emotional state. Lessons based on technology, through the involvement of the playful component and through their specific dynamics, increased the degree of commitment to the students' task. At the same time, the lessons offered the opportunity to learn at their own pace, to return to those more difficult lesson sequences and to ask the teacher for additional explanations, which led to an improvement in the evaluation results, a fact that contributed to an increase in confidence in their own problem-solving abilities.
An interesting aspect emerged from the discussions with the students at the end of the lessons in the focus groups: when asked to what extent they felt anxious during these lessons, the students stated that, in some lessons, they were scared by the novelty of the teaching style and the fact that they will not be able to use the technology correctly. This type of answers are more frequent in the group of students with higher educational abilities. However, at the end of the pilot they declared that the level of anxiety decreased after the first 2-3 lessons after they got used to the technology and the devices, but also due to the fact that their teachers were with them and provided them with additional information when they needed it.
Thus, the use of modern technologies in the education of students with hearing disabilities proves to be efficient in stimulating motivation for learning and self-confidence when they are used appropriately and with the active and permanent involvement of teachers. Additionally, these technologies enhance the accessibility of educational content, allowing for greater flexibility and personalized learning experiences tailored to individual needs. As a result, they contribute to improved academic performance and foster a more inclusive educational environment that promotes equal opportunities for all learners.

Acknowledgments

This work was supported by the European Union's Horizon 2020 Research and Innovation programme via Grant Agreement no. 688503 for the NEWTON project (http://newtonproject.eu) and GIVE – „Governance for Inclusive Vocational Excellence", the Erasmus+ Program, KA3 Support for Policy Reform, 621199-EPP-1-2021-1-IT-EPPKA3-VET-COVE

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