THE IMPACT OF THE WILDLIFE NEWTON VIRTUAL REALITY APPLICATION AND VIRTUAL LAB ON KNOWLEDGE ACQUISITION IN STUDENTS WITH SPECIAL EDUCATIONAL NEEDS

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Abstract

This research paper investigates the impact NEWTON Wildlife – a combined Virtual Reality (VR) and Virtual Lab (VL) application has on knowledge acquisition, learning experience and children perception on STEM topics when deployed to learners with hearing impairments. 30 children with hearing impairments aged between 13 and 15 from St. Maria School, Bucharest, Romania took part in a case study. The children were exposed to two learning sessions that involved two Wildlife stages labelled Wildlife part 1 and Wildlife part 2. Wildlife part 1 provides a nature VR environment that introduces a number of wild animals with their habitat life, whereas Wildlife part 2 offers a virtual lab that provides a 3D close view of the animals explored in Wildlife part 1. The evaluation process consisted of knowledge pre- and post- tests administrated to all participants before and after their interaction with the Wildlife application. STEM motivation and affective state questionnaire was also administrated before interacting with the Wildlife application and at the end of the learning session.

Results analysis of the collected data shows an increase in knowledge acquisition for all students. A t-test for paired-sample shows that the difference between means of the pre-test and post-test, for both lessons, are statistically significant. This study underlines the benefits of NEWTON technologies as virtual reality and virtual laboratory in the learning experience of children with hearing impairments.

Keywords: Special Educational Needs, Technology-Enhanced Learning; Augmented Reality, Virtual Reality, Virtual Labs.

1 INTRODUCTION

Using Technology Enhanced Learning (TEL) in today's education is one of the most popular research topics and especially in learning STEM related subjects. Significant efforts have been put in order to make progress in this area by devising different innovative TEL solutions and introducing them in students' and educators' daily life [1], including students with special educational needs.

Researches in the fields of psychology, special education and educational sciences [2] [3] have demonstrated the unmapped possibilities of developing the potential of a person with a certain disability, the possibilities of his/her integration and social affirmation under conditions of support services provided by society through educational, therapeutic, rehabilitation and functional compensation oriented activities. One of the general features characterizing children with special educational needs, regardless of their type, is the limited access to information [4]. This limited access to information often leads to failure in school activities. For this reason, one of the constant challenges for teachers is to find ways to adapt information to the level of understanding of children with special educational needs.

Research work on various TEL teaching approaches has proved benefits on learners' knowledge acquisition when technology is embedded into the learning process. For example, Virtual Lab (VL) and Virtual Reality (VR) technologies can provide knowledge gain benefits to students and can motive them to learn especially those STEM topics that are found to be difficult to gasp. A 3D maths virtual lab for secondary school students is presented in [5] and it enables visualisation of 3D objects. A VR environment that offers 360-degree visualisation of the Solar System, relative distances and planets' size is proposed in [6] as part of an astronomy course. The employment of immersive VR in different STEM areas has showed higher knowledge gain and knowledge retention.

A VL application is a highly interactive three-dimensional multimedia environment that provides a simulation of the real world and it includes sound, real-time motion and tactile capabilities that enable users to gain practical experience. Examples of VL applications proposed for STEM topics include: Virtlab[1] - a platform that provides series of virtual hands-on experiments specific to a chemistry laboratory; VccSSe[2] provides virtual labs and training in physical laws including simulation-based exercises. Many of the proposed VR and VL applications were not designed to accomodate special education needs despite previous research showing that technology based learning can improve the learning experience of students with disabilities [20].

In this context, NEWTON Project developed an educational platform (called NEWTELP) that integrates diverse novel technologies in education such as adaptive multimedia and multi-sensorial media [7, 8, 9], personalization [10], virtual labs and fabrication labs [11, 12, 13]. These technologies were combined with self-directed teaching pedagogies such as problem-based learning, flipped-classroom and game-based learning [14, 15, 16] in order to provide support for children with special learning needs. This research paper analyses the outcome of a case study in terms of knowledge acquisition, learning experience and students' perception on learning STEM topics when using the Wildlife application, as part of Earth Course large scale STEM education pilot deployed in the context of the NEWTON project. The study was carried out in" Sfanta Maria" school from Bucharest, Romania - a special vocational school for children with hearing impairments.

The rest of the paper is structured as follows: section 2 describes the Wildlife application that uses VR and VL technologies, section 3 describes the evaluation methodology applied in this case study, section 4 presents the results analysis, while section 5 concludes the paper.

2 WILDLIFE APPLICATION DESCRIPTION

The Wildlife application is part of the EU Horizon 2020 NEWTON Project – large scale Earth Course pilot [17] and it was deployed at St. Maria School, Bucharest, Romania, a special vocational school for students with hearing impairments. The NEWTON project designs, develops and deploys innovative technology-rich solutions for delivering STEM content. These technologies include adaptive and personalized multimedia and multiple sensorial media (mulsemedia) delivery, augmented and virtual reality, virtual teaching and learning Labs, and fabrication labs. In order to demonstrate the benefits of the NEWTON Project technologies, proof of concept educational VR and AR applications, educational games VL and multimedia and mulsemedia content that focus on STEM topics were developed and tested in over 20 pilots across different European countries at primary, secondary and third education levels [11, 13, 18, 19].

Figure 1: Wild Life Application Screenshots

The Wildlife application was developed by the NEWTON project partner SIVECO from Romania. It involves 3D immersive computer-based VR and VL simulations and provides educational content on a set of animals, including deer, wolf, wild boar, fox, moose, brown bear, hare and lynx. Two separate environments are created to explore the animals: a nature VR environment, where the learners need to find the animal in its own habitat and learn about it and a VL environment, where a closer 3D view of each animal is presented as well as additional educational information is offered related to the

[1] VirtLab http://www.virtlab.com/

[2] VccSSe - Virtual Community Collaborating Space for Science Education, http://www.vccsse.ssai.valahia.ro/.

animal. Considering that the application was used in a classroom of students with hearing impairment, the entire educational information was translated into sign language. The educational content provided by the application was designed in collaboration with teachers.

3 EVALUATION METHODOLOGY

The learning session about the wild animals spammed over two class sessions. During the first session the nature VR environment provided by Wildlife application was used (also called Wildlife part 1) while the Wildlife VL environment (called Wildlife part 2) was used during the second session. The evaluation methodology of the Wildlife application consisted of knowledge pre- and post- tests administrated to all participants before and after each of the two learning sessions. Motivation and affective state questionnaires were also administrated before interacting with the Wildlife application for the first time and at the end of the second learning session in order to assess their learning experience.

The purpose of the knowledge pre- and post- tests was to evaluate student knowledge on wild animals before and after interacting with the Wildlife application. Both sets of questions (pre-test and post-test ones) assess the same learning outcomes. The questions of the knowledge tests were designed with the help of teachers with slight question variations. Paired t-test for knowledge test mean values were used to investigate whether statistically significant differences exist between pre-test and post-test results.

STEM motivation and affective state questionnaire consisted of 5 questions and assessed the learning experience though the NEWTON environment as well as students' perception on learning STEM topics. The answers for the questions were on a 5-level Likert scale, ranging from strongly agree to strongly disagree. A number of 30 children (34.1% females and 65.9% males) with hearing impairments aged between 13 and 15 took part in the case study and provided answers to the various tests and questionnaires.

4 RESULTS ANALYSIS

Results analysis in terms of knowledge gained and learning experience is presented next for each of the two part of the Wildlife application. Knowledge gained was measured as the different between the average scores for the pre and post tests. Children's learning experience is assessed through an analysis of the answers distribution.

4.1 Knowledge Gained Analysis

Figure 1 shows the mean scores for the pre-test and post-test assessments of all students. The average post-test scores, in both lessons, (3.76 points for Wildlife Part 1 and 3.93 points for Wildlife Part 2) showed an evident improvement compared to the average pre-test scores (1.83, respectively 1.70). Most of the students have shown knowledge improvement after using the NEWTON Wildlife VR-VL application. The results of a paired t-test for means confirmed statistical significance between the two tests, for both lessons at $\alpha = 0.05$ ($t(30) = 9.032$, $p=0.00$ for Wild Life 1and $t(30) = 7.303$, $p=0.00$.for wild Life 2).

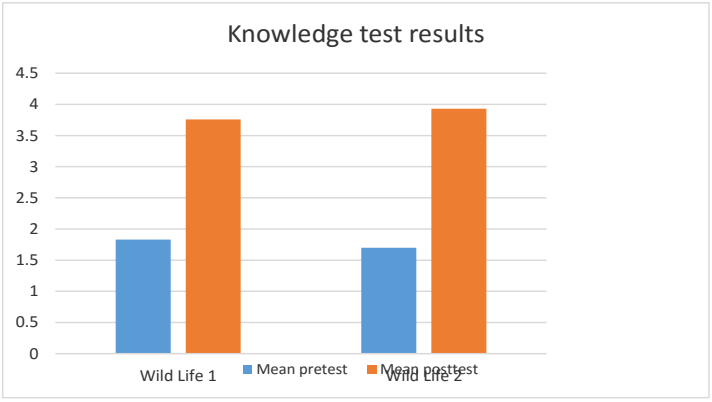

Figure 2: Knowledge pre-test and post-test average scores for Wildlife Part 1 and Part 2

4.2 Analysis of Affective State and Usability of Technologies

The evaluation of affective state and attitude towards STEM learning was carried out through a questionnaire applied before and after interacting with the Wildlife application. The questionnaire has also assessed participants' opinion regarding NEWTON technologies as a learning environment.

Table 1. I find learning science, technology and maths boring.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)	Variation (%)
Strongly disagree	7.3	4.9	-2.4
Disagree	2.4	47.0	+44.6
Neutral	39.0	36.0	-3
Agree	29.0	7.2	-21.8
Strongly agree	22.3	4.9	-17.4

The participants were asked to assess the degree of boredom in the science learning activities. Most of them opted for Level 3 (39 %), meaning a state of neutrality. 7.3% of students can not in any case be described as boring. Before being exposed to the NEWTON technologies, 51.3% of participants agreed or strongly agreed that STEM learning activities are boring, when the classical pedagogical approach is used. However, this percentage significantly degreased after the use of the Wildlife application and only 12.1% still believed that STEM learning activities are boring.

Assessing changes in the perception of boredom in learning science after using NEWTON shows that the highest change at group level is for the ”disagree” option compared to the ”neutral” option.

The degree of self-perceived difficulty in learning the science topics is illustrated in Table 2. 39.1% of students ”agree” and ”strongly agree” that they find difficult to study STEM topics, while the highest frequency corresponds to neutral answers (36,6%) in terms of perceiving the difficulty in learning the STEM.

Table 2. I find learning science, technology and maths difficult.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)	Variation (%)
Strongly disagree	2.4	7.3	+4.9
Disagree	24.4	39	+14.6
Neutral	36.6	24.4	-12.2
Agree	22	24.4	+2.2
Strongly agree	17.1	4.9	-12.2

After using NEWTON in learning the perceived difficulty in learning science has also decreased. Thus, 29.1% of participants find learning STEM difficult and very difficult. Although, this percentage is high, however it is lower than the value obtained (39.1%) before the use of technology.

In terms of usefulness more than half of the participants (51.2%) consider that learning with NEWTON has effects in terms of increasing efficiency perceived during science lessons. No participant stated that the NEWTON approach has no links with the efficiency in the activity (level 1 was not chosen by any student). 7.3% of students believe that the use of NEWTON technology is in a direct and strong relationship with effective participation.

Table 3. NEWTON lesson helps me be more effective in a science class.

N	30
Mean	3.54
Std. Deviation	.809
Minimum	2
Maximum	5

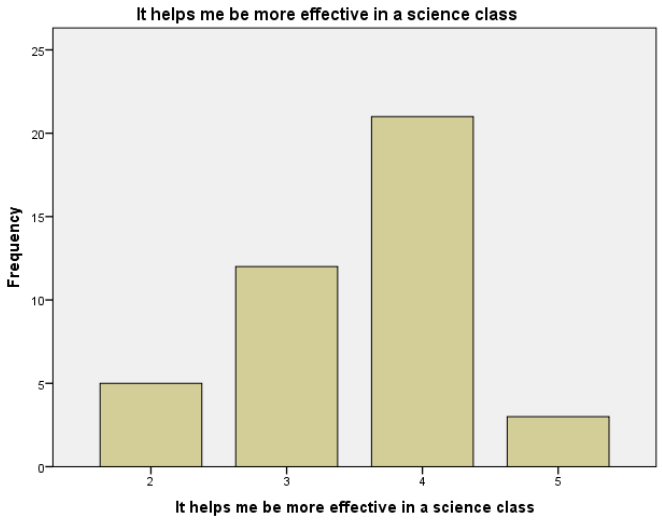

Figure 3: Self-perceived efficiency in the classroom when using NEWTON technologies

The easiness of using technology in the learning process is confirmed by a total of 85.3% of the participants. The highest frequency of responses converges to level 4 (39% of participants). Also, 26.8% of participants strongly agree that NEWTON technology is easy to use.

Table 3. It is easy to use.

N	30
Mean	3.68
Std. Deviation	1.213
Minimum	1
Maximum	5

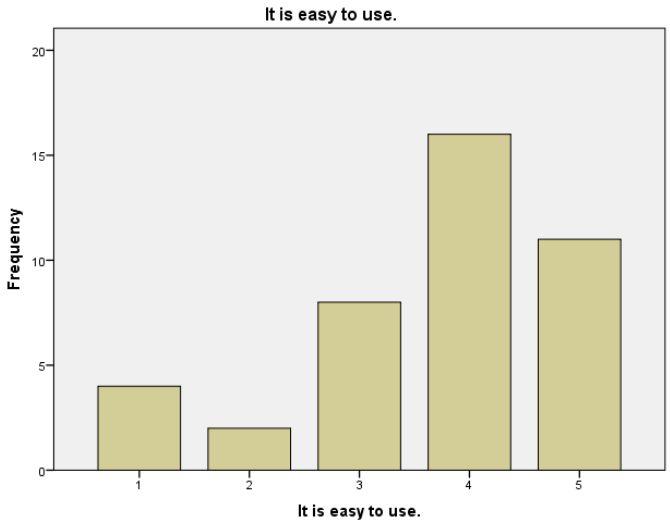

Figure 4: Easiness of using NEWTON technologies

5 CONCLUSIONS

This research paper investigated the benefits that Wildlife application (part of the Earth Course Large Scale Pilot) and the NEWTON technologies (VR and VL) bring to students with hearing impairments in terms of knowledge acquisition and students perception on learning STEM topics. The Wildlife application - which are mainly based on the use of the following technologies: 3D immersive computer-based VR and Virtual Laboratory – was deployed in two separate lessons (one hour per lesson) with 30 students with hearing impairments at a special school for children with hearing impairments - Sfanta Maria school form Bucharest, Romania.

The case study analysis investigated the children knowledge level gained on wild animals before and after the use of the NEWTON Wildlife application. The analysis has shown a significant improvement in the knowledge acquisition for all the students that were evaluated.

This study underlines the benefits of NEWTON technologies as virtual reality, virtual laboratory, in the learning experience of students with hearing impairment and showed how these technologies can bring benefits to learners including a better knowledge acquisition.

An important aspect emerging from this study is that the acquisition of knowledge has been achieved in a pleasant environment. In addition, the technologies used in the Wildlife application were perceived as being easy to use. Not at last, a higher number of children had a positive attitude towards learning STEM topics after their exposure to the NEWTON technologies.

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