ENHANCING LEARNING EXPERIENCE OF CHILDREN WITH HEARING IMPAIRMENTS WHEN EXPOSED TO NEWTON SEALIFE VIRTUAL REALITY APPLICATION

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Abstract

There is an increasing interest in offering rich educational content not only to students with typical development, but also to students with special educational needs. This paper demonstrates the benefit of using Sealife – a Virtual Reality (VR) and Virtual Lab (VL) application in terms of learning experience when deployed to children with hearing impairments. The Sealife application consists of two parts: a 3D immersive computer-based VR and a VL simulation. For each sea creature introduced in the first part of the application there is a nature VR environment, and learners are asked to search for the animals in their own environment and learn different facts related to them. In the second part of the application, the learners are exposed to a VL environment that provides a 3D view of the animals and additional educational information related to them.

Results of a pilot study deployed in St. Maria School from Bucharest, Romania, involving 30 secondary school students with hearing impairments are presented in this paper. Children learning satisfaction was assessed using a motivation and affective state questionnaire. The analysis of the results demonstrated a significant improvement in the motivational and affective state of the children in terms of interest in STEM subjects, self-confidence and enjoyment.

Keywords: Virtual Reality, Virtual Labs, Technology-Enhanced Learning, Students with Hearing Impairments

1   INTRODUCTION

Recently, the school activities focus not only on acquiring knowledge but also on creating a pleasant and attractive learning environment. Most of the time, learning STEM topics is not associated with a positive affective state. Many students show anxiety over these topics and consequently the motivation to study STEM subjects decreases. Often teachers are in the position to seek new ways to motivate students to learn science, technology and mathematics

Emotional experiences and motivation are deeply involved in all learning processes influencing attention [1], memory [2], reasoning [3] and problem solving activities [4] etc. Identifying solutions to improve learner affective state and to motivate him/her during the class sessions is the key element for an effective learning.

In this respect, the EU Horizon 2020-funded NEWTON project focuses on integrate innovative pedagogical learning approaches and technology enhanced learning (TEL) materials in order to stimulate learners' motivation and affective state during lessons, encourage their engagement and improve learning outcomes [15, 16, 17]. NEWTON Project educational material is distributed through its platform - NEWTELP. This platform provides courses as well as assessments from multiple angles, such as knowledge gain, usability and affective state [5]. NEWTELP platform provides educational materials and integrates diverse novel technologies in education including adaptive multimedia and multi-sensorial media [10, 14, 18, 19], personalization [20], virtual labs and fab labs [10, 12, 20].

This paper analyzes learners' motivation and affective state after the use of the VR-VL Sealife application, as part of Earth Course NEWTON large scale STEM education pilot that was carried out in "Sfanta Maria" school - a special vocational school from Bucharest, Romania for students with hearing impairments A total number of 30 students participated in this case study.

2   SEALIFE APPLICATION DESCRIPTION

The Sealife application combines Virtual Reality (VR) and Virtual Lab (VL) technologies and it was developed by the NEWTON Project consortium partner, SIVECO from Romania. The application focuses on the aquatic world as part of the NEWTON Earth Course Large Scale Pilot [8, 13]. The application introduces educational concepts on various water animals, including dolphin, jellyfish, octopus, orca, turtle, clownfish, puffer fish, seahorse, shark and stingray. Each maritime animal is presented through two separate environments: Nature VR environment, where the learners are required to interactively find an animal and learn about its style of leaving, and Virtual Laboratory (VL) environment that offers a 3D view of the animal together with additional educational information relating to it. Figure 1 illustrates the information provided by the application for clownfish. Considering that the lesson was used in a classroom of students with hearing impairment, all the information was translated into sign language.

a)   *Clownfish in Nature VR Environment*   b)   *Clownfish in VL Environment*

Figure 1 NEWTON Sealife application

The Sealife application is part of the EU Horizon 2020 NEWTON Project – large scale Earth Course pilot [11] and it was deployed in the Special Vocational School for students with hearing impairments at St. Maria School, Bucharest, Romania. The NEWTON project designs, develops and deploys innovative technology-rich solutions for STEM content delivery. These technologies include adaptive and personalized multimedia and multiple sensorial media, Augmented and Virtual Reality, Virtual Labs and Fabrication Labs [6, 7, 8, 9, 10]. A large set of educational VR, AR and VL applications, games and multimedia and mulsemedia content that focus on STEM topics was developed and deployed across different European countries at primary, secondary and third education levels [10, 12, 13, 15].

3   METHODOLOGY

The NEWTON project involves the design and implementation of innovative technologies and modern pedagogical approaches that provide educational content and contribute to the assessment of the many benefits that they bring to learning such as: acquiring knowledge, motivating for learning, affective status, usability etc. The Sealife application was part of Earth Course Large Scale Pilot that took place in two primary schools from Ireland, Slovakia and Romania. The pilot focuses on four main areas: Atmosphere, Geosphere, Biosphere and Astronomy. The case study presented in this paper is part of the pilot that took place in Spring 2018 over a one-month period and with a frequency of three lessons per week. This pilot included 41 children with hearing impairments, ages 11 to 18 from the Sfanta Maria, Bucharest. A subgroup of 30 students with different level of hearing impairment (from mild to severe) have used the Sealife application as part of two lessons.

The educational content provided by the Sealife application was selected in collaboration with school teachers to ensure that the information presented is in line with the school curriculum and is suitable for students with hearing impairment.

Both lessons were provided through the NEWTELP platform, and the activities were conducted by school teachers in the presence of a NEWTON researcher. In this pilot, lessons that make use of NEWTON technologies have been applied as methods of teaching information. Thus, it was possible to evaluate the efficiency of using NEWTON technologies as a teaching method for students with hearing impairment.

The assessment methodology was defined by the NEWTON Pedagogical Assessment Committee and presented in [3]. During the design of the evaluation process, various stages were followed. Before the deployment of the educational content in the school, the approval of the Ethics Committee of the University of Bucharest was obtained, certifying that this assessment process complies with all research ethics conditions. Subsequently, meetings were organized with students, who were going to participate in this project along with their parents and a short presentation of case study to be performed was presented. Then, the Informed Consent Form and Assent Form were provided to be signed by the parents and by the students in which they expressed their agreement to participate in the study.

The Evaluation process consisted of the following:
- 2 activities took place before the participants interacting with the Sealife application and its technologies:
    o Demographic Questionnaire provided to the participants
    o Affective and Motivation state questionnaire regarding traditional science classes was distributed to the students
- 1 activity took place after the interaction with Sealife application:
    o Affective, motivation state and attitude regarding STEM questionnaire provided to the students

4   RESULTS ANALYSIS

Starting from the characteristics of the material to be taught, it was considered a good opportunity to known the emotional state of the students related to the study of the STEM subjects before interacting with the NEWTON technology. A 5-points Likert scale was used to collect the answers for the Affective and Motivation State questionnaire. No students stated that they did not like at all learning STEM subjects. Levels 3 and 4 were most often indicated by students to illustrate their emotional states about learning STEM (see table 1). 48.8% of the students said it is O.K. to learn science, technology and maths, 45.1% like to learn STEM related subject and only 4.9% said that they love to learn the subjects.

Table 1. How do you feel about learning science, technology and maths.

	%
1	0
2	4.9
3	48.8
4	41.5
5	4.9

Students answers were evaluated on a 1 to 5 scale. An analysis of the answers provided to the question "Do you get good marks in science, technology and maths?" shows that there was no answer on level 1 and only one answer on level 2 (M=3.85, SD= 0.69). A large percentage of the participants (58.5 %) noted that the grades in the exact disciplines are above average (level 4) and 24.4% of them get average results.

Table 2. Do you get good marks in sciences, technology and maths?

Answers level (1- 5)	% of Answers
1	0
2	2.4
3	24.4
4	58.5
5	14.6

Reporting students interest in science classes, before using NEWTON technologies it can be noticed that most of the them have a medium interest (36.6%), with only one student reporting a particular interest in science (2.4%), 4.9% of students reported a low interest in science.

Table 3. Interest in science classes.

	Before using NEWTON technologies	After using NEWTON technologies
1	4.9	0
2	34.1	19.5
3	36.6	26.8
4	22	46.3
5	2.4	7.3

An analysis of students' level of interest in science related activities after using the NEWTON Seallife technology illustrates that the answers are in the 2-5 interval. There is no response on level 1 (not interested at all) as in the initial case. A particular interest is indicated by 7.3% of the students (compared with 2.4% before using the NEWTON Sealife) and 46.3% of them have a high interest (level 4- very interested).

Perceived self-efficacy on science was also evaluated through the following question "How confident are you that you can solve any challenges in science class?". The maximum level of confidence (level 5) in solving the problems and challenges was reported by only 4 students (9.8%), while levels 2 and 3 had the highest frequencies and also the same frequencies (36.6%) before using NEWTON Sealife technologies.

Table 4. Self-confidence in science classes.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)
1	2.4	0
2	36.6	29.3
3	36.6	24.4
4	14.6	36.6
5	9.8	9.8

After Sealife application was used in the class, increased perceived self-efficacy in the field of sciences was noticed., The highest frequency (36.6%) is given at level 4 (very confident). 9.8% of the students are considered to be particularly confident in their capabilities, while 29.3% still have low confidence in their own capabilities in the indicated context.

Table 5. Engagement during science lessons.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)
1	14.6	14.6
2	12.2	9.8
3	29.3	26.8
4	36.6	43.9
5	7.3	4.9

Assessing the level of feeling engaged during the science class, it was observed that the highest frequency was obtained for level 4 (36.6% of students), followed by level 3 (29,3%). In addition, the two low levels of involvement accumulated together a frequency of 26.8% before using the modern technologies provided in the Sealife application.

An analysis of the level of engagement in a science class that uses the Sealife application shows that the highest frequency is 43.9% and belongs to level 4 (as opposed to the level 3 reported before the exposal to the NEWTON technology). A very high level of involvement is reported by 4.9% of pupils. The average level of involvement (level 3) was declared by 26.8% of students.

An analysis of the answers provided to the question *"While you were learning in your science class, to what extent did you feel enjoying?"* shows that 41.5% of the students enjoy the science classes and have indicated for this state level 4 while only 7.3% of them really enjoyed STEM classes. On the

other hand, 9.8% of students indicated the lack of enjoyment during a science class session (as reported in the prior technology stage).

Table 6. Enjoyment of the science lessons.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)
1	9.8	2.4
2	14.6	12.2
3	26.8	29.3
4	41.5	48.8
5	7.3	7.3

Summarizing, it is evident the increase of the level of class enjoyment after using the Sealife technologies. In this respect, 48.8% of the students reported that they enjoyed Sealife lessons while before these lessons, 41.5% of them were feeling the same. Only 2.4% of participants reported the lack of pleasure to participate in learning with NEWTON support compared to 9.8% of students that stated that do not enjoy learning STEM before their exposal to the Sealife application

Table 7. I feel positive during science lessons.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)
1	0	2.4
2	17.1	4.9
3	41.5	41.5
4	31.7	34.1
5	9.8	17.1

A particular positivism in learning STEM topics was indicated by only 9.8% of the students before using the NEWTON Sealife application. Level 1 (the absence of positive feelings) was not chosen and almost half of the students (41.5%) opted for the average level (level 3) as an indicator of positivism in learning STEM.

After exposal to the Sealife lessons, the percentage of the students that have a neutral opinion about feeling positive during lesson remains the same (41.5 %). We can observe in table 7 that the number of students that are feeling positive increase after using Sealife application (34% felt positive and 17.1% felt very positive on learning about sea animals using NEWTON technologies). However, it can be observed that 2.4% of the students do not feel positive.

Table 8. Interest in science lessons.

	Before using NEWTON technologies (%)	After using NEWTON technologies (%)
1	0	0
2	14.6	7.3
3	17.1	21.8
4	46.3	48.8
5	22	22.1

The interesting character of science lessons is perceived by 46.3% of the students as above average (level 4), 22% consider these activities to be particularly interesting, and for low interest opted 14.6% of students. The interest in science in learning with NEWTON was considered by 48.8% of the students to be very high by indicating the level 4 (compared to learning without NEWTON the highest frequency was for the same level, but for 46.3%) and for 22.1% of them being absolutely special (level 5). The drop in the number of students who think STEM is not interesting shows NEWTON's benefits.

In order to determine the enthusiasm level in learning and how this is influenced by using textbooks or modern technologies, the students were asked to say to what extent they agree with the following

statement: "Using textbook/NEWTON make me more enthusiastic about learning sciences". The answers showed that majority of the students agreed and strongly agreed with the fact that using NEWTON make them more enthusiastic about learning STEM lessons (56.1%) while majority of them disagreed and strongly disagreed (36.6), and 43% had a neutral attitude about using textbooks in learning STEM

Table 9. Enthusiasm in learning by using textbooks/using NEWTON technologies in science classes.

1.	Using textbook make me more enthusiastic in learning (%)	Using NEWTON technologies make me more enthusiastic in learning (%)
1	14.6	2.4
2	22	4.9
3	43	36.6
4	19.5	48.8
5	0	7.3

5   CONCLUSIONS

The Sealife lessons provided as part of the Earth Course Large Scale NEWTON pilot and presented in this research paper were investigated in terms of their impact on motivation and affective state of students with hearing impairments. The lessons were offered to 30 students with hearing impairments from the Sfanta Maria special school for hearing impairments from Bucharest, Romania. An affective and motivation state questionnaire was applied before and after students' exposal to the Sealife application. The analysis of the results demonstrated a significant improvement in the motivational and affective elements in terms of interest in STEM topics, self-confidence and enjoyment.

This study underlines the benefits of NEWTON technologies such as VR and VL for learners with hearing impairment including: a positive attitude during the lessons associated with an enjoyable learning environment; increase in interest in learning STEM lessons; and a better affective state during these lessons. Another aspect shown by this study is that NEWTON approach builds confidence amongst STEM learners in their own capability to solve problems and to have success in learning process.

Due to the close relationship between affectivity and motivation, it is important to analyse the level of the two processes amongst the students. The result of the teaching-learning activity is directly proportional with the level of the two processes. Enthusiastic participation in activities provides the degree of motivation necessary to sustain that activity. When the enthusism grows, as happened with the subjects involved in this study, their academic motivation for the science lessons increased proportionally and their learning improved.

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