LEARNER MOTIVATION CASE STUDY IN STEM EDUCATION TECHNOLOGY ENHANCED LEARNING

This paper presents a Technology Enhanced Learning science, technology, engineering and maths (STEM) education case study, Earth Course, carried out in two primary schools in Dublin, Ireland as part of the European Horizon 2020 NEWTON Project. The Earth Course provides learners with educational content on the following main topics: Biosphere, Geosphere, Astronomy and Physics using digital applications developed as part of the NEWTON Project, employing technology enhanced learning (TEL). Two 5th classes participated in each school, where one of the classes interacted with the NEWTON approach as an introductory tool, with 30 boys in one school and 30 girls in the other school and the other class as a revision tool following the usual instruction by their teacher, with 30 boys in the first school and 27 girls in the second. This paper is focused in the assessment of learner motivation and affective state following the Earth Course case study. Most students found the Earth Course interesting and they would like to use similar lessons in other science classes. Students were extremely positive about the use of technology in the classroom, seeing it as a supporting tool for their teacher.

Keywords: STEM education, Technology in education and Training, Primary School

INTRODUCTION AND BACKGROUND

TEL is one of the proposed solutions to enhance learners' engagement with STEM subjects, particularly when a lack of interest toward these subjects has been observed in recent times (Henriksen, 2016). Beneficial impacts of the TEL approach have been in noted in various research papers, such as (Ibáñez, Serio, Villarán, & & Kloos, 2014), (Daineko, Dmitriyev, & Ipalakova, 2017) and (Ak & Kutlu, 2017). Horizon 2020 NEWTON Project has the objective of increasing learner quality of experience and learner engagement at the same time maintaining or increasing the learning outcomes in STEM subjects, for all levels of education, starting with primary level when learners are more open to new approaches. In order to achieve its objective, NEWTON project employs a variety of TEL approaches and various pedagogies, including multimedia and multiple sensorial media (Bi, et al., 2018), (Bi, Silva, Ghinea, & Muntean, 2018), personalisation, Virtual Labs (VLs) (Lynch & Ghergulescu, 2018), gamification (Lynch, et al., 2018), fabrication labs (Togou, et al., 2018), Augmented Reality (AR) and Virtual Reality (VR) (Bogusevschi, et al., 2018), problem-based and game-based learning (El Mawas, et al., 2018). All NEWTON Technologies and its Gamification Portal are embedded on the **NEW**TON **TEL P**latform (NEWTELP)[1] (Bogusevschi, Muntean, Gorji, & Muntean, 2018).

EARTH COURSE: SET-UP, PARTICIPANTS AND EVALUATION PROCEDURE

The *Earth Course* case study was set up to assess the effect of NEWTON technologies, such as Virtual environments, including Virtual Labs, game-based learning, gamification and of the NEWTON Project platform, NEWTELP, on primary school learners' motivation and affective state. The main research question is: What is the impact of NEWTON Technologies and platform on learners' motivation and affective state? Table 1 provides an overview of the topics within the *Earth Course* and the specific application within each topic. It also includes the main technology used and a brief description of the learner activities within each application.

The *Earth Course* case study was carried out in two single sex primary schools, St. Patrick's Boys National School (BNS) and Corpus Christi Girls National School (GNS) in Dublin, Ireland and it meets all ethics

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requirements. Two 5th class groups participated in each school with learners of 10-11 years of age. Classes A and A' in St. Patrick's BNS and Corpus Christi GNS respectively employed the NEWTON approach as an introductory tool to a topic and classes B and B' were initially presented the educational content by their usual teacher in a teacher centred approach, following which, 4 to 10 weeks later they interacted with the NEWTON applications to review the previously presented content. The NEWTON Project Pedagogical Assessment Committee Assessment Toolkit (Montandon, et al., June 2018) was used to evaluate the intervention, whereby at the beginning of the intervention, two questionnaires were completed by learners - Demographics and Affective State/Motivation Pre-questionnaires. Following the completion of the 8 learning sessions, learners completed the Affective State/Motivation Post questionnaire in order to determine students' motivation toward STEM and their engagement. Interviews and focus groups were also conducted with learners.

Table 1 Earth Course Case Study Applications

Topic	Application	Technology	Description
Biosphere	Wildlife I Wildlife II[1]	VR, VL, gamification	Learners explore a nature environment collecting gas-cans in a forest and finding terrestrial animals, which are then explored in a VL. Quick quizzes are provided in order to reach the bonus level.
	Sea-life I[1] Sea-Life II[1]	VR, VL, gamification	Learners explore a nature environment collecting star-fish in an ocean and finding aquatic animals, which are then explored in a VL. Quick quizzes are provided in order to reach the bonus level.
Geosphere	Geography[2]	AR, VR	Learners need to familiarise with digital educational content focused on UK and the Republic of Ireland where images of monuments with enabled AR/VR functionality are provided. A Virtual Map is then employed for assessing learners' geographical knowledges.
Astronomy	Final Frontier I[3]	Gamification game-based learning	Game with an avatar on a spaceship which focuses on Rocky Planets, allowing for an exploration of virtual planets, where learners need to collect meteorites and answer quizzes.
	Final Frontier II[3]	Virtual library	Virtual library that exists on the spaceship and provides educational information about the giant Gas Planets and the Rocky planets.
Physics	Water Cycle in Nature[1]	VR, VL	Learners explore a virtual nature environment learning about phenomena participating in precipitation formation and a VL which exhibits relevant physics experiments in a laboratory setting.

EVALUATION OF CASE STUDY IMPLEMENTATION

Following completion of the *Earth Course*, during focus groups and interviews, the majority of learners reported being very engaged in the NEWTON lessons. It was reported quite strongly in groups A' and B, that they perceived NEWTON as a very useful supporting tool for the teacher, especially during the focus group where students reported being very excited about the classes where the content was provided by both the teacher and reinforced by the NEWTON approach. Students reported enjoying the TEL approach together with the teacher for support and direction.

From the data in the Motivation/Affective State Post questionnaires, the majority of students were interested in the relevant subjects, where around 60% of learners in B and B' classes were very or extremely interested (65% of boys and 60% of girls), with an even higher percentage in classes A and A' (85% of boys and 70% of girls). While the majority of all the students responded that they were somewhat or very engaged, the female students responded more positively (90% of girls and 70% of boys). Only one girl in class A' reported boredom. The implementation of the technology in introducing the topic was considered more favourably by

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the students than its use as a revision tool (with over 80% of learners in classes A and A' indicating the NEWTON lessons were extremely interesting, and 53% of boys' class B and just over 62% of girls' class B' responding similarly). The students' preference in the use of technology in STEM subjects remains quite stable compared to before the *Earth Course* case study, with 85% of boys in class A wanting to use more technology (compared to 92% in the questionnaire prior study), 76% of boys' in class B (compared to 77% prior study), compared to 72% (with 74% prior study) and 64% (with 60% prior study) of girls respectively. Comments from students include: "I like NEWTON very much […] thank you so much for teaching me about the earth space and nature", in class A' and "I think I preferred doing the game it made it more interesting" in class B'. Boys' answers included "I really enjoyed NEWTON" in class A and "Games are more fun" in class B. Further analysis of the data will probe the learning gains presented by the technologies and the comparison of uses in the different class groups. Interview data form teachers will be used to support data analysis.

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