A STUDY OF LEARNING SATISFACTION WITH A MULTI-SENSORY MEDIA DELIVERY SYSTEM

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Abstract

In recent years, immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and Multi-Sensorial Media (MulSeMedia) have brought new dimensions to gaming, video entertainment, e-learning and other aspects of human life, increasing their immersiveness. This paper describes an Adaptive Rich Media Solution (ARM) introduced to support adaptive delivery of video, audio and mulsemedia content including haptics, air motion and smell in the context of the European Horizon 2020 project NEWTON. The paper presents a study of learning experience when mulsemedia-based study material is distributed using ARM to 48 participants in a real-life subjective experiment. In the study user Quality of Experience (QoE) was evaluated and its impact on participant learning in third level education context.

Keywords: learning satisfaction, multi-sensorial media, adaptation, technology-enhanced learning.

1 INTRODUCTION

The rapid growth and development of computer science and communication technologies have also influenced positively technology enhanced learning (TEL). Mulsemedia-enhanced learning is one of the TEL solutions introduced to make learning process more attractive. In traditional multimedia-based learning, research and technology developments target usually two human senses only and focus on improving the image and/or sound quality [1]. This limitation stimulates the disconnection between the user and the represented scene, relationship which could benefit from enhancement through combinations of audio-visual content with one or several different types of other stimuli (e.g., haptic and/or olfactory).

With growing interest in TEL in general and immersive learning in particular, very much effort has been invested in solutions to complement multimedia-based TEL. Various technologies and media have been used to enhance learning including virtual reality (VR), augmented reality (AR), mixed reality (MR) and mulsemedia [2]. VR is becoming an affordable reality as the cost of wearable headsets is continually reducing, AR and MR are opening new possibilities in the immersive learning space and mulsemedia content adds support for an improved learning experience.

This paper presents a research study on learner experience when a new Adaptive Rich Media Solution (ARM) was used to deliver multi-sensorial media elements, engaging three or more human senses. The proposed ARM allows for adjustment of the real learning content delivery according to existing delivery network conditions and user profiles.

The study is part of the EU Horizon 2020 NEWTON project[1] whose main objectives are to design, implement, integrate and disseminate TEL applications and innovative learning approaches. The NEWTON project investigates the impact of using innovative technologies such as VR, AR, virtual labs, adaptive and personalised multimedia and multiple sensorial media [12, 13, 14]. Innovative pedagogical approaches such as problem based learning, flipped classroom and game-based learning and gamification [15, 16, 17] combined with the above mentioned technologies were deployed in over 20 STEM education-related small and large scale pilots.

The research study described in this paper adaptively delivers mulsemedia content and assesses the benefit of employing the latest technologies in the learning process in terms of learner satisfaction, user quality of experience (QoE) and learning outcome. The study has involved 48 third educational level students who have accessed mulsemedia content via the NEWTON project platform NEWTELP.

[1] http://www.newtonproject.eu/

2 RELATED WORKS

Diverse efforts in mulsemedia research have been forthcoming. For instance, there have been a few studies [3-7] carried out to investigate the user-perceived experience associated with the use of the newer media objects such as tactile (touch) and olfactory (smell). However, because the use of these media objects is relatively new in the multimedia field, most of these perceptual studies have concentrated their efforts on the practicality and possibility of incorporating these media objects into applications [3].

One such research effort is a VR learning system called VIREPSE which provides both olfactory and haptic feedback [4]. An earlier mulsemedia VR learning environment from the same group of researchers was one in which research investigated the effect of olfaction on learning, retention, and recall of complex 3D structures such as organic molecules in chemical structures [5]. However, neither of the two studies report on any detailed evaluation of either of these applications, but rather focus their research efforts on discussing the significance of developing such mulsemedia virtual environments for education.

Indeed, synchronization seems to be a common theme across mulsemedia research. Thus, recent work has explored synchronization of olfactory media with audio-visual content [6], whilst [2] investigated synchronisation issues between different modalities, as well as the integration of video and haptics in resource constrained communication networks–a topic closely related to the work described in this paper.

To the best of our knowledge, the only effort exploring adaptive mulsemedia is that of Yuan et al. who have proposed ADAMS [7] - an adaptive mulsemedia framework for delivering scalable video and sensorial data to users. Unlike existing two-dimensional joint source-channel adaptation solutions for video streaming, the ADAMS framework includes three joint adaptation dimensions: video source, sensorial source, and network optimization. Using a MPEG-7 description scheme, ADAMS recommends the integration of multiple sensorial effects (i.e., haptic, olfaction, air motion, etc.) as metadata into multimedia streams. ADAMS design includes both coarse- and fine-grained adaptation modules on the server side: mulsemedia flow adaptation and packet priority scheduling.

The Adaptive Rich Media Solution (ARM) described in this paper was introduced and designed as part of the EU Horizon 2020-funded NEWTON project. The NEWTON project bridges the gap between the development of latest technologies and classic education by providing educators and students with modern solutions and tools to enable improved and more attractive teaching and learning, with special focus on STEM education. Some previous work on employing adaptive multimedia content and delivering multiple sensorial media content in educational contexts was reported in [8-11].

3 CASE STUDY

The aim of the research study is to investigate learner satisfaction when educational material involving multi-sensorial content is used in the teaching process.

3.1 Evaluation Methodology

The effect of using NEWTON ARM mulsemedia technologies on knowledge gain and learner satisfaction on students was examined in the Slovak Technical University of Bratislava (STUBA), Slovakia. The evaluation meets all ethics requirements, so prior to running the case study, approval was obtained from STUBA Ethics committees. All ethics-associated forms were provided to the students, including plain language statement, informed consent form, and data management plan. Students took part on the experiment following their free decision, being interested on the topic. A total of 48 college students took part in the NEWTON project mulsemedia tests and provided answers to the various tests and questionnaires. Paired t-test for means were used to show whether there exist statistically significant differences between pre-test and post-test results.

The evaluation has 7 steps which were followed by the researchers. In *Step 1*, prior to beginning of the evaluation, the consent forms were distributed to the students who were asked to sign them. In *Step 2*, the students were introduced to the research case study. In *Step 3*, the plain language statement which included a detailed description of the testing scenario, information on study purpose, participant identity protection info, etc. was presented to the students. In *Step 4-6*, the students had roughly 30 minutes to watch 6 mulsemedia clips via the NEWTON project platform: NEWTELP. Each clip was associated with a two-question pre-test and six-question post-test questionnaires to evaluate learner experience. Finally, in *Step 7*, a learner satisfaction questionnaire has assessed student learning experience.

3.2 Participants

In this pilot, we have attracted 48 students from computer science or engineering departments in STUBA. Most of students are first year undergraduate students, their majority (97.98%) are below 25 years old, and 54.17% of student's are below 20. Regarding gender distribution, there was a high rate of males at around 85.42%. Only 20.83% of the participants had worn glasses. All the participants were using Dell laptops to run the NEWTON adaptive mulsemedia learning content. More than half (52.08%) of the multimedia contents are delivered to the laptops via Ethernet (i.e. cable network) and 43.75% of the laptops were using a wireless network to stream the content.

3.3 Case Study Set-up

The mulsemedia sequences were generated by enhancing multimedia videos (with a resolution of 1920x1080 pixels and a frame rate of 30.3 fps) with multi-sensorial content, i.e., haptic, air and/or olfaction effects. The video content focuses on energy harvesting, renewable energy and climate change, as follows:

- Solar: energy harvesting from solar and electromagnetic field sources.
- Kinetic: energy harvesting from kinetic sources (e.g. by spinning the mobile devices or the vibration on a car), and wind.
- Hydro: Energy harvesting from hydro based sources.
- Football: Multimedia content adaptation when watching a football match in a park.
- Coffee shop: Multimedia content adaptation during a video call in a coffee shop.
- Car: Multimedia content adaptation when remotely attending a concert while on a car.

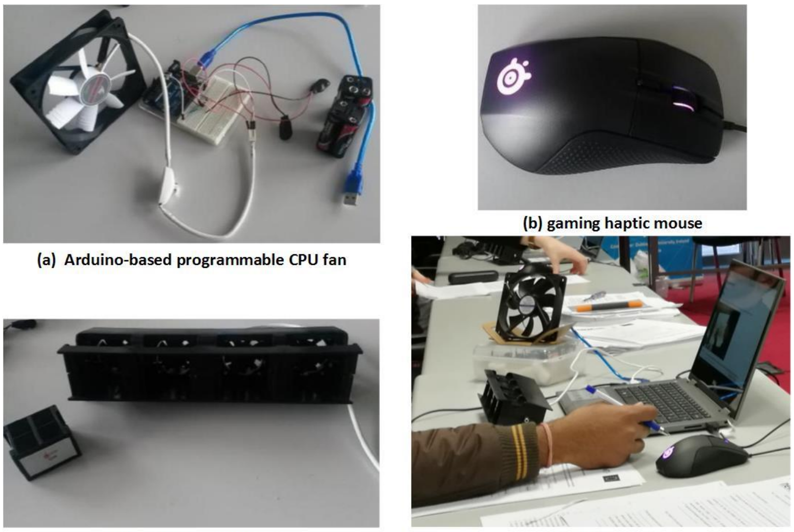
Table 1 details the duration and multi-sensorial effect settings related to each mulsemedia sequence.

Table 1 Duration of the mulsemedia effect of each video

Video	Duration (m)	Mulsemedia effects and sync time (s)		
		Air	Haptic	scent
Solar	1:13	5s	9s	Oak: 9s
Kinetic	0:53	8s	11s	Diesel: 8s
Hydro	1:25	7s	5s	Oak: 10s; Ocean: 5s
Football	1:24	12s	8s	Oak: 12s;
Coffee shop	0:57	10s	10s	Chocolate: 12s
Car	0:49	10s	10s	Diesel: 10s

Three different scenarios were set with all 6 mulsemedia sequences. In scenario 1, no multi-sensory effect happens during the video display; in scenario 2, all three multi-sensory effects (wind, haptic, olfaction) occur and the olfaction scent is relevant to the video content; in scenario 3, all three multi-sensory effects occur, but the olfaction scent is always "Candy", regardless of the content scent.

To present the mulsemedia effect to the end users, the ARM mulsemedia player makes use of additional multi-sensory actuator equipment, which illustrated in figure 1. A gaming haptic mouse, an Exhalia scent diffuser and an Arduino-based programmable CPU fan were used to generate haptic, olfaction and air-flow effects in sync with multimedia content.



(a) Arduino-based programmable CPU fan
(b) gaming haptic mouse
(c) Exhalia scent diffuser
(d) subjective test

Figure 1 Mulsemedia Equipment and Test-bed

According to the content scenario, the multi-sensory effects were manually synchronized with the corresponding sensorial content in the multimedia clips by setting the start and end timestamps. Then, the "mulsemedia segment file" is generated by a multi-sensory data annotation tool in ARM.

3.4 Learner satisfaction result

In this section, we illustrate the results of the learners' satisfaction questions.

The learner satisfaction was investigated and evaluated by questions Q1 to Q7 in the Learner satisfaction questionnaire. It was analyzed in terms of: number of Strongly Agree/Agree answers for Q1, Q2, Q4, Q5, and Q7 and Strongly Disagree / Disagree for Q3 and Q6.

The seven questions of the learner satisfaction, related to the multi-sensorial experience, are listed next:

- Q1. It helped me to better understand the concepts.
- Q2. It helped me to better assimilate the concepts.
- Q3. It did not improve my learning experience.
- Q4. It helped me to engage in the learning process.
- Q5. I enjoyed the experience during the class.
- Q6. Its effects were disturbing for me during the class.
- Q7. I would like to have more classes/labs/courses that include multi-sensorial experience.

The overall learner satisfaction of the participants was excellent (see figure 2 for detailed results). 43.75% confirmed that the multi-sensorial experience helped them understand better the concepts. 56.25% thought that the multi-sensorial experience helped them to assimilate better the concepts. 43.75% thought the multi-sensorial experience helped them to be more engaged in the learning process. 62.50% enjoyed the multi-sensorial experience during the class. 54.14% would like to have more activities that include multi-sensorial experience. 25% disagreed that the multi-sensorial experience did not improve their learning experience. 45.83% disagreed that the multi-sensorial effects were disturbing for them during the class time.

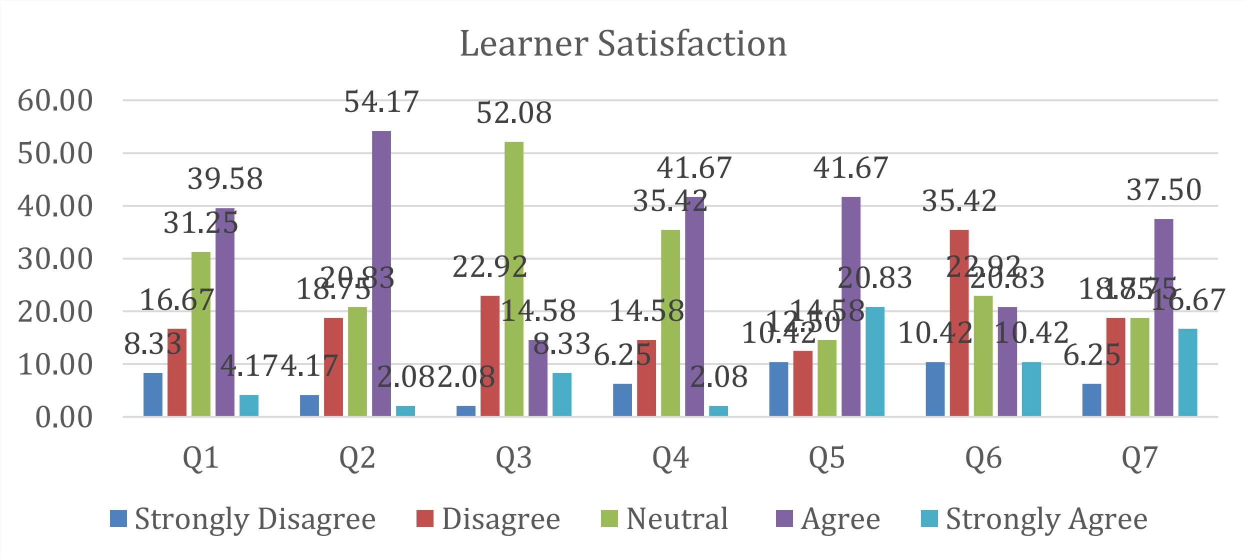


Figure 2 Learner Satisfaction

4 CONCLUSIONS

An analysis of the results collected in a case study conducted on a group of 48 students was presented in this paper. Learner outcome with olfaction via the ARM and learning satisfaction experience were investigated. The analysis of the satisfaction survey results shows that the majority of the students were satisfied with the multi-sensorial experience: 62.5% of them enjoyed the mulsemedia. The survey also shows that the students appreciated various multi-sensorial effects and that they enhanced the learning outcome. Based on the feedback from students shows that they seemed very happy, having a good time during the NEWTON mulsemedia pilot. These emotions were distinctly manifested by students' cheer and applause when successfully completing a task/activity. This implies that ARM can be used as a complementary tool to the classical teacher-based approach to encourage students to learning.

ACKNOWLEDGEMENTS

This research is supported by the NEWTON project (http://www.newtonproject.eu/) funded under the European Union's Horizon 2020 Research and Innovation programme, Grant Agreement no. 688503.

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