R&E-SOURCE *http://journal.ph-noe.ac.at*
Open Online Journal for Research and Education
Special Issue, December 2017, ISSN: 2313-1640

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Impact of an augmented reality learning environment on teacher motivation in an in-service training on creative multimedia technology

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Abstract

This study investigates the impact of an augmented reality learning environment on motivation.
In the in-service training Creative Multimedia Technology, teachers were introduced to the principles of designing educational videos. The participants were introduced to the topic in hands-on activities: They used their smartphones to turn static pictures into animated ones. After this input, they participated in the German adaptation of the survey *Intrinsic Motivation Inventory* and rated the educational video types. Then they implemented their newly acquired knowledge and skills to produce their own teaching videos. The evaluation of the questionnaire shows that the AR learning environment can promote intrinsic motivation. Thus, the produced videos impressively show that the basic principles for video design were put successfully into practice.

Keywords:
Augmented Reality
Motivation
Teacher Education

Schlüsselwörter:
Augmented Reality
Intrinsische Motivation
LehrerInnenbildung

1 Introduction

In the 21. century digital technology has reached all fields of our society. Knowledge is no longer in the autonomy of a few but is available on the World Wide Web anytime and anywhere. To succeed in work, life and citizenship learning and innovation skills (critical thinking, communication, collaboration and creativity) as well as information, media and technology skills are needed. Students have to be prepared for a global technological society and teachers need competencies and knowledge to connect learners in a connected world (Partnership for 21. Century Learning, 2015; ISTE, 2017). The challenge for pre- and in-service teacher education institutions is to develop Technological Pedagogical Content Knowledge (TPACK). This shape of knowledge is essential to integrate technology in classrooms as a learning tool. The improvement of the TPACK model is the connection of content knowledge, pedagogical knowledge and technological knowledge (Angeli & Valanides, 2009; Mishra & Köhler, 2006). Pre- and in-service teachers have to experience how technology can change educational settings and which pedagogical methods are possible with multimedia. In this paper the in-service training Creative Multimedia Technology is described. In this seminar the participants learned about the design principles for educational videos, how they can produce such videos with their pupils in schools and ways to transform the videos in augmented reality elements. Instead of traditional teaching the learners were introduced to the principles with an open augmented reality (AR) learning environment. With the newly acquired skills the design principles for educational videos have been put into practice. Additionally new teaching methodologies have been learnt such as flipped classroom and open learning spaces with AR. The impact of this environment on teacher motivation is being tested with a German version of the *Intrinsic Motivation Inventory* (Ryan, Koestner, & Deci, 1991). According to the self-determination theory human motivation is linked to the need of autonomy, collaboration and competence. If a learning environment can satisfy these needs learners are more interested in the offered topic and didn't have the feeling to practice

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under pressure. Freedom of choice is one characteristic within the self-determination theory (Ryan & Deci, 2000). Thus the learners in the open augmented reality environment had the free choice how much time they wanted so spend for each AR element and also the starting point was selectable. For Deci & Ryan (1993) this is one chance of promoting intrinsic motivation in education.

2 Learning with Augmented Reality

Augmented Reality (AR) is one of the top educational technology trends since 2010. The Horizon Report (NMC) assumes a positive impact on learning, creativity and education but the technology was not available on consumer devices. This changed with the rise of smartphones, tablet computers and the appropriated platforms (e.g. iOS, Android,...) (Yuen, Yaoyuneyong, & Johnson, 2011, p. 120). Nowadays, everything a learner needs is a mobile device with camera and an AR application (e.g., Aurasma). Recent surveys from Austria and Germany show that 95% of twelve to nineteen year old students own such a device and 75% of young adults (16-29) in Europe use the Internet on their mobile phone (JIM, 2016; Education Group, 2015; eurostat, 2015). In summer 2016 the game *Pokémon Go* made AR available for the mass and showed what it is and how it works. Since then 750 million downloads of the app have been registered and more than five million active users keep the game still alive (Smith, 2017).
For Azuma (1997) AR is the coexistence of real and virtual objects in the same space and with real time interaction. Klopfer and Sheldon (2010) define augmented reality (AR) as *"(..) a situation in which a real world context is dynamically overlaid with coherent location or context sensitive virtual information"* (Klopfer & Sheldon, 2010, p. 205). Milgram et al. (1994) proposed the Reality-Virtuality-Continuum (Figure 1) with two extremes, the real environment and the virtual environment. Virtual environments are currently known as virtual reality and can be defined as environments that are totally simulated by technology (Yuen, Yaoyuneyong, & Johnson, 2011, p. 121). Between these opposites two types of so-called mixed reality occur. For AR real environment is used as background and computer-generated content is displayed. The other type is augmented virtuality where a computer-generated environment acts as backdrop and real-world objects show up (Milgram & Kishino, 1994).

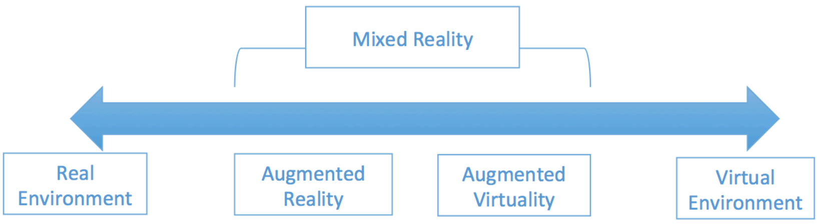

Figure 1. Reality-Virtuality Continuum, own representation, based on Milgram & Kishino, 1994

Many researchers have already shown that AR can have a huge impact for learning. Klopfer & Sheldon (2010) summarize the potential of AR as *„(...)to enable students to see the world around them in new ways and engage with realistic issues in a context with which the students are already connected."* (Klopfer & Sheldon, 2010, p. 86). Dunleavy & Dede (2014) pointed out that there are topically two versions of AR possible for educators. Location-based AR is linked to GPS-enabled smartphones or devices, which locate the learner in a specific habitat. Then a multimedia content is displayed which provides relevant information's about the location. An example for location-based is Wikitude, which provides specific data about sights in a city or an upcoming narrative about the habitat when passing by a tree. The other version is vision-based AR. To project the virtual information a trigger image/object is needed. When this image/object is scanned with camera virtual objects like text, sounds, videos, animations, 3D models or images appear. An example is a trigger image near a tree which shows a 3D model of the structure when the camera is focused on it (Dunleavy & Dede, 2014). In this research also a vision-based AR learning environment will be discussed.
As for all technology enhanced environments it is important to think about pedagogical aims and learning theories, which can promote the learning process. For AR Dunleavy & Dede (2014) suggest situated learning theory and constructivism learning theory as the most important ones. Learners can improve their knowledge and skills like problem solving while acting in a real-world and social-context. Five conditions of constructivist learning theory can enhance learning with AR:

- Learning within relevant environments
- Enable social negotiation experience
- Provide multiple modes of representation
- Provide self-directed and active learning options
- Support metacognitive strategies

Educators and students reported that learning environments with AR allow creating situations with a problem-based approach. These problems can then be solved with collaborative methods like role-play or jigsaw. The possibility to provide unrealized learning opportunities is a benefit too (Dunleavy & Dede, 2014).

2.1 Impact on learning effects

Research showed that AR could support learning in a more effective way than other technology enhanced environments. If content is represented as 3D learners can manipulate objects and handle information's in a interactive way (El Sayed, Zayed, & Sharawy, 2011). Collaborative AR applications can improve spatial abilities (Kaufmann & Schmalstieg, 2003; Kaufmann, Steinbugl, Dunser, & Gluck, 2005) and an authentic AR environment can help understanding dynamic models and complex causality (Rosenbaum, Klopfer, & Perry, 2007). In clinical medicine an AR system collected data about the learners performance. Subsequently the system transformed the information's to visual and immediate feedback to support the psychomotoric skills (Kotranza, Lind, Pugh, & Lok, 2009). An AR game on science allowed students to organize, search and evaluate data and educated their navigation skills (Klopfer, 2008) as well as other new skills can be facilitated with AR (Mathews, 2010; Feng, Duh, & Billinghurst, 2008). Stanton et al. (2003) reported about AR in museum education and summarized that AR can contribute to student's understanding history in an authentic way. Buchner & Zumbach (2017) provided an AR learning environment for pupils in a secondary school in Austria to learn about witch tracing at the beginning of the modern times. The kids explored the content with their smartphones and the app Aurasma. Every AR element introduced to a specific topic and made a learning task available. The offered tasks provided the imparting of knowledge and the facilitation of historical and political competencies which are part of the curriculum (Buchner, 2017a). The comparison of the pre- and post-knowledge-test suggested an increased knowledge after interacting with the AR learning environment.
Ferrer-Torregrosa et al. (2016) compared a flipped classroom scenario with AR in anatomy learning. The students learned about the intrinsic muscles of the foot with videos and 3D models. The analysis of the survey indicated a more effective learning with the 3D graphics within the AR setting. Santos et al. (2016) designed a situated vocabulary learning content with ARToolKit (Kato & Billinghurst, 1999). Compared to a non-AR learning content no differences were found in a temporary post-test. A delayed test about vocabulary retention offered a bigger difference in favor of AR content.
Additionally to the improvement of content knowledge learning with AR can support collaboration, physical task performance and language learning (Radu, 2014).

2.2 Impact on motivation

Several studies observed the influence of AR learning environments on students' motivation. The users' showed a high enthusiasm while interacting with the AR experiences and reported a higher satisfaction compared to non-AR learning. Also the willing to repeat was higher within an AR setting even though it was more difficult than the offered non-AR environment (Radu, 2014). Santos et al. (2016) tested an AR model for vocabulary learning and found a positive impact on satisfaction and attention. Similar results have been detected by Freitas & Campos (2008), as they developed an AR learning system for transportation and animal types for 2nd grade students in Portugal. In Spain a visual art course about Italian Renaissance was taught with and without AR. The group learning with AR showed a moderately higher motivation compared to the non-AR learning group. Also increased interest and attention for the learning content has been found. Very important for the observed students was the control over the presented learning materials and the learner-centered tasks and activities, which made the whole experience more engaging for them (Di Serio, Ibáñez, & Kloos, 2013). An increase of interest has also been explored by Sotiriou & Bogner (2008). Giving students the control for their learning was also the idea of Buchner (2017b) as he designed an open learning environment with AR for history education. The findings suggest that the AR learning environment can promote intrinsic motivation because of an increase of interest, perceived freedom of choice and experience of competency.

2.3 Limitations

If educators want to implement AR within their classrooms some challenges must be into consideration. From the technological perspective a device with camera and/or GPS is needed. Most of the applications are also addicted to Internet access. The pedagogical point of view must change if AR is used in a learning process. A teacher-centered approach can hinder successful knowledge construction, thus a student-centered and explorative character of learning is necessary (Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Wu, Wen-Yu Lee, Chang, & Liang, 2013). Important for teachers and lectures is the flexibility of the AR system. Many systems don't allow changes of the content, therefore AR authoring tools are essential to regard the specific needs of the learners. Furthermore the use of AR can cause cognitive overload or the feeling of confusion because of the mixed perception of real and virtual environment (Wu et al., 2013). Attention tunneling, usability difficulties and learner differences are some other challenges to think about (Radu, 2014).

3 Case study

For this research the in-service teacher-training course „Creative Multimedia Technology“ was designed as an AR learning environment. The participants learned about the design principles for educational videos by scanning static pictures with the application *Aurasma*. Every picture then revealed an animated one (short video clip) with information about optimal length, possible narration forms, interactivity and educational video types like stop motion, animation, green screen and whiteboard movies. With previous research in mind the AR learning was provided student-centered, in a social context (e.g. working in groups) and with free choice opportunities like free order and timing (Di Serio et al., 2013; Dunleavy & Dede, 2014; Kerawalla et al., 2006). According to self-determination theory those factors can promote intrinsic motivation in educational contexts (R. M. Ryan & Deci, 2000a, 2000b). Therefore in this research a German version of the *Intrinsic Motivation Inventory* survey is used. Wilde, Bätz, Kovaleva, & Urhahne (2009) tested this short scale of intrinsic motivation for a museum visit and found strong validity for the items. They also recommend adapting the scale for other autonomous learning scenarios.
Additionally the impact of the AR environment on the learning progress is discussed by analyzing the produced videos considering the design principles for educational videos. To evaluate which educational video type teachers prefer for their own production the participants have also ranked the presented video types. The results of the ranking will be compared with the produced videos.

3.1 Research questions

The purpose of this study was to investigate the impact of an open AR learning environment on teacher motivation and the transfer of the knowledge into practice. The following research questions are discussed:

1. Are the participants interested in the offered content?
2. Do the participants perceived free choice?
3. Is learning with this environment learning under pressure?
4. Have the taught design principles been put into practice?
5. Is there a correlation between video type ranking and the produced video types?

3.2 Materials and sample

The course took place at the University College of Teacher Education Lower Austria. Seventeen teachers participated in the in-service training and the survey, six male, eleven female.
The lecturer produced the materials for the AR learning environment with the application Aurasma. This is an AR authoring tool that allows educators to design AR elements. For the production first a trigger image (= picture which is scanned later) is needed. After the upload of the picture an overlay (= virtual information which is presented) appropriate to the trigger image is superimposed. In this case study short videos were used as overlays. For every educational video type one video was provided. Also for the design principles of

educational videos two clips made available. The first scene of the films served as trigger images to generate the come-alive effect. The lecturer also arranged the applied movies.

3.3 Procedure

The participants of the course were introduced to the setting of the AR environment. First they had to download the application *Aurasma,* second a login is required. The lecturer provided an account for everyone so that it was not necessary to invest an own one. This is also a good hint for teachers in school, because kids had a lot of accounts on different platforms, but can't remember the passwords for them.
After that the teachers arranged them in groups of four and started with the exploration of the AR learning environment. The trigger images have been placed in the whole University College, so also movement was part of the learning experience.
As survey instrument an adapted version of the short scale of intrinsic motivation (Wilde et al., 2009) was used, supplemented with the questions about the video types.

4 Results

4.1 Motivation

The descriptive analysis of the short scale of intrinsic motivation has been done with SPSS Statistics 24. Table 1 shows the means, standard deviation and the internal consistence (Cronbachs' Alpha) for each scale. Every scale is composed of three items, e.g. one item for *Interest/Enjoyment* is *The AR environment was worthwhile*.

Scale	Mean	Standard Deviation	Cronbachs Alpha	Items
Interest/Enjoyment	11,41	1,121	,772	3
Perceived Choice	10,94	1,784	,748	3
Pressure/Tension	1,12	2,147	,852	3

Table 1: Descriptive statistic of the questionnaire

The results in Table 1 show a high approval within the scale *Interest/Enjoyment*, what tends to confirm research question one. The same applies to research question two, as the high mean score for the scale *Perceived Choice* supports the awareness of free choice opportunities among the participants during their learning process. The results for the scale *Pressure/Tension* indicate that the in-service teachers felt no fear or pressure while the AR experience. Similar results have been found in other studies using this questionnaire (Buchner, 2017b; Buchner & Zumbach, 2017; Wilde et al., 2009).

4.2 Learning effects

Research question four handles the transfer of new skills and knowledge into practice. The attendees produced eight video clips and the themes were freely selectable. Table 2 provides an overview of the videos including topic, title, video type, length and the applied design principles.

Topic	Title	Video type	Length	Visualization	Storytelling	Activation
Deciduous trees	Which deciduous trees do you know?	Laying technique	4:00	YES	NO	YES
Computer technology	How a computer works – Part 1	Whiteboard	2:00	YES	YES	YES
Computer technology	How a computer works – Part 2	Whiteboard	2:06	YES	YES	YES

Geography	Austria and its federal states	Green Screen & Laying technique	2:24	YES	NO	YES
Ski run rules	Frosti explains the ski run rules	Stop Motion	1:17	YES	YES	YES
Bathing rules	Herbert explains the bathing rules	Laying technique	2:52	YES	YES	YES
Handicrafts	Let's build a birdhouse – Part 1	Animation	1:39	YES	NO	YES
Handicrafts	Let's build a birdhouse – Part 2	Animation	1:20	YES	NO	YES

Table 2: Overview of the produced videos

The overview in Table 2 confirms research question four. All videos were shorter than six minutes (Guo, 2013) and integrated two or more design principles for educational videos (Brame, 2015; Schön & Ebner, 2013). Visualization and activation are main elements to engage learners during watching videos. Also the keep it short rule is very important so that the films will be watched until they are finished. The potential of storytelling was used in four out of eight videos, which suggests that the participants would have needed more information's and/or help to realize this principle.

4.3 Preferred video types

The in-service teachers were asked to rate the educational video types. Table 3 shows the ranking and whether the type was used for their own productions.

Rank	Mean	Type	Used (how often)
1.	1,35	Stop Motion	YES (1)
2.	1,41	Whiteboard	YES (2)
3.	1,47	Green Screen	YES (1)
4.	1,65	Tutorials	NO
5.	1,71	Animation	YES (2)
6.	1,76	Simple Show	NO
7.	1,82	Screencast	NO
8.	2,18	Laying Technique	YES (3)

Table 3: Ranking of the video types

The high ranking of the first three video types and their number of usage tends to support research question five. But the low ranking of three times used laying technique and two times applied animation needs a closer look at the results. Producing an educational video with laying technique is easier than doing a screencast or a tutorial, because no new software skills are necessary. Everything learners need are paper forms, pencils and smartphones with video function. No additional technology is required, which makes this video type also handy for school lessons and more attractive for teachers, even if this type of video doesn't quite fit into their idea of an educational video. A previous computer game developer who has already been familiar with appropriate software designed the two animation videos. This special case can be classified as an exceptional.

5 Summary and discussion

The results revealed that the in-service teacher training with AR supported interest/enjoyment and perceived choice, disadvantages because of pressure have not been detected. Following self-determination theory (Ryan & Deci, 2000a) the environment promoted intrinsic motivation among the seventeen participants. Similar results have been found by Buchner & Zumbach (2017). The main differences are the high means for both positive related scales. This tends to reveal that in-service teachers' appreciate AR and especially open and social learning contexts. Learning within such environments is necessary to foster innovation and technology skills (ISTE, 2017; Partnership for 21. Century Learning, 2015). So the in-service teachers' experienced such a learning environment and rated it as interesting, a higher chance of integrating similar learning opportunities in their schools is believed. Furthermore the participants gained knowledge and skills on how to create educational videos. Pedagogical concepts about how to integrate educational videos (e.g. flipped classroom, AR learning) in classrooms have also been discussed. Thus it is assumed that this seminar could help to develop TPACK (Angeli & Valanides, 2009; Mishra & Köhler, 2006).

The learning effect of the AR environment becomes apparent through the designed educational videos. Skills and knowledge have been acquired by AR and successfully put into practice. All clips took account of the keep it short rule (under six minutes) and used two or more design principles.

No clear answer can be given to research question five. The attendees liked the video types stop motion and whiteboard, thus they also appear in their own productions. Laying technique was ranked low, but used three times. This can be explained because of its easy and school suitability handling compared to more technology-heavy video types.

Limitations of this study are the small sample and the missing control group. Also one scale (perceived competence) of the short scale of intrinsic motivation is missing, because no tasks have been offered straight during the AR experience. Future research should compare the facilitation of skills and knowledge between learning with and without AR, especially in pre- and in-service teacher trainings. More relevant is, if such experiences, which integrated pedagogical concepts and new technology, have an impact on lesson planning and/or mindset about schooling.

Summarized it can be said that AR has a huge potential to motivate learners and to promote skills as well as knowledge. If educators want to use this special technology, student-centered, social and active learning methods are urgent. Possibly, experiences with AR can change teachers' attitudes about schooling towards a more learner-centered teaching style.

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