Conceptual Model for the Use of Smart Glasses in Ubiquitous Teaching (u-teaching)

Full Paper

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Abstract

Smart glasses, a wearable headset technology, currently trending provides hands-free and augmented reality features. This paper looks at the research around mediated-reality tools to improve the delivery of education. Despite its potential, it has not seen widespread use in education. A suitable implementation framework and pedagogy have been proposed so that smart glasses can be used towards creating digitally-mediated learning (DML) environments. Aurasma is recommended as the implementation framework after a comparison with other frameworks based on factors such as cost, ease-of-use, and accessibility among others. For a suitable pedagogy, new assessment strategies, content personalization, and the use of 3-D learning spaces are recommended. It is argued, that the recommended framework and the pedagogy approach have the potential to improve learning environments for teachers and students. However, there are privacy concerns due to the pervasive nature of Augmented Reality (AR). In the current research, the overall learning environment is considered.

Keywords: Smart Glasses, Google Glass, Smart Learning, Pedagogy, Wearable Technology

1 INTRODUCTION

The service design and delivery of teaching has changed from blackboards, chalks and paper-based book to a whiteboard which may use a smartpen, a projector, and books which are mostly online. Despite being online, the content is still restricted in two dimensions. The main motivation for this research is to propose applications of smart glass in classrooms so that the traditional methods of teaching can leverage from digital learning environments that utilize the benefits of mediated reality and learning (Wu et al. 2013). Moreover, advancement in learning has not progressed beyond 'mobile learning' which refers to learning with wireless and mobile communication technologies. The widespread use of mediated reality in the form of headsets is yet to be seen. As a first step, we need to understand why teachers adopt a certain technology? It can then help us to find ways to adapt modern technology even if it is disruptive to service design.

U-learning refers to a learner's ability to interact with learning systems and to access digital resources, ubiquitously (Hwang 2014; Liu and Hwang 2010). A u-learning system is also termed as a "Smart Learning Environment" (SLE), which actively provides learning guidance, supportive tools, hints, or learning suggestions by taking in contextual information about the time and place and about the learner. It allows for learning to take place in the real-world with access to data from the digital world. Dron (2018) suggests thinking about SLEs as an "emergent consequence" of the interactions taken between the environment structures, which in our case are, the learner and the teacher. Therefore, any environment can be smart if it uses the right elements in the right manner.

Smart Glasses (SGs) are an optical head-mounted display or a wearable headset technology with the capability to reflect the projected images coined as "mediated-version of reality" (Mann 2013) by Steve Mann. Google introduced the first commercial version of SG and named it "Google Glass," in its well-known "Project-Glass" in the year 2012. Initially, it came as a replacement to the smartphones (Albanesius 2012), however, even after six years, the technology struggled to capture the mainstream public adoption (Heinzman 2019). Google Glass ended the retail availability in January 2015 and Intel planned the shutdown of "Vaunt", their version of SGs project in 2018 (Dieter Bohn 2018). Most of the issues with the technology are because of security and privacy as it is designed to have a camera that has no way of showing/informing people whether they are being recorded or not (Hofmann et al. 2017). Nonetheless, Google and other companies continued working on industry applications. Google also moved from an 'explorer edition' to 'enterprise edition' specially designed for industries.

Since its start, SGs has seen several applications in real life in the fields of engineering and medicine. Engineers in the aviation industry have been using to while performing maintenance and repair on to improve efficiency. Hence, it is fair to deduce that the content creation in augmented-reality tools designed specifically for learning environments, can positively affect the wide-spread adoption of the technology (Figueiredo et al. 2013).

Unlike other wearable technologies such as smartwatches, SGs are only being used in some industries, therefore it is important that its applications in education should be explored promptly. Accordingly, this paper will discuss "*how teachers can create effective digitally-mediated learning environments using smart glasses?*" after studying the factors which persuade teachers to adopt a certain technology for teaching. This paper terms it Ubiquitous Teaching (u-teaching).

Without an easy-to-use framework that could allow academics to create effective content for the students, the technology cannot survive. Therefore, the paper also presents "*a comparison of SGs' content creation frameworks*" which are currently available in the market. This is a conceptual paper, which will be further explored empirically.

The remaining paper discusses the relevant literature and a conceptual framework that outlines using SGs during student-teacher interaction. The paper concludes with the discussion on the futuristic approach of using SGs in the classrooms.

2 RELEVANT LITERATURE

The literature explores themes of technology-adoption by teachers for content delivery and design, the Digitally Mediated Learning (DML) environments, the potential of SGs, and content creation technologies (Figure 1). It should also be noted, that there are other venues to explore in this research, such as how students will see the use of SGs in DML environments. How the DML environments will affect the traditional student-teacher relationship etc.

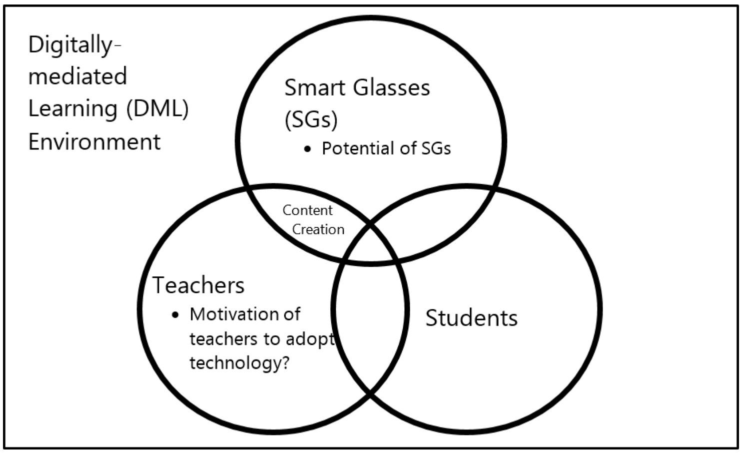

Figure 1: Literature Outline

2.1 Technology Adoption by Teachers

Even though there is evidence of several educational benefits of technology, teachers generally adopt it in a limited manner (Zheng et al. 2019). The barriers could be inadequate training, negative peer experiences, or time constraints (Moser 2007). The years of teaching and age also negatively affect their computer proficiency while teacher's beliefs and readiness positively influence the integration of technology (Moser 2007).

An empirical study conducted on school teachers' technology adoption reveals complex technology from a *users' perspective* has a greater chance of abandonment. However the *innovators and early adopters* will use the technology irrespective of its complexity (Aldunate and Nussbaum 2013). The inventors are defined as the teachers who are technology-driven, while early adopters are the ones who have a positive attitude towards technology. The early adopters often do not get reliable support or get negative student feedback and therefore, do not continue. A faculty e-learning behaviour process starts from the time commitment to competence development to reflection, with full support from the institution's administrative body (Almarzooqi 2019; Moser 2007; Zheng et al. 2019).

Hastie (2019) defined Smart-Learning Environment (SLE) as dynamic, where they provide need-based guidance to students by teachers. In a robotics lab, they taught Science, Technology, Engineering and Mathematics (STEM) to the students in Abu Dhabi. The results concluded that the use of such SLEs provide in engaged, collaborative and efficient feedback to both students and teachers (Altinpulluk 2019).

Locklear (2018) mentions that SGs can give teachers the "superpowers", as it distributes teachers' time more among struggling students. It is argued that at the moment, there is a lot of confusion about the adoption of the technology, but once, they used with full potential there will be no turning back (Kelly 2018; Locklear 2018; Wells 2014).

The researchers referred to *portability* as a barrier to use any technology by teachers (Altinpulluk 2019). Portability refers to the usage of augmented-reality tools in the outdoor. However, it is proposed as one of the benefits of SGs (Moshtaghi et al. 2015) as these can be used anywhere, at any time.

2.2 Digitally Mediated Learning (DML) environments

Such learning environments or pedagogical approaches are also referred as SLEs or u-learning (Liu and Hwang 2010; Wu et al. 2013), "Intelligent Tutoring System"(ITS) (Dron 2018), and "adaptive learning systems" (Graf et al. 2010; Peng et al. 2019) learning through gamification (Yee 2013), and personalised learning (Peng et al. 2019). However, advancement in learning has not progressed beyond 'mobile learning' which refers to learning with wireless and mobile communication technologies. The widespread use of mediated reality in the form of headsets is yet to be seen.

The SLEs are active learning spaces mediated by technology that can sense the learners' behaviour, automatically record their learning process, and is able to evaluate their learning accomplishments, shared by the facilitator and the student (Huang et al. 2017; Hwang 2014; Liu and Hwang 2010).

As cognitive psychology, artificial intelligence and computing started to converge the researchers started to work on learning environments that use digital technologies ("Intelligent Tutoring Systems" (ITS)). The teachers soon realised that the three have the potential to offer students an environment that can make "instruction in context" possible with "immediacy of feedback" (Anderson et al. 1985 p. 461).

"Adaptive learning systems" evolved as the technology advanced. Such systems support students to learn by adapting to the technological interfaces (Graf et al. 2010). Researchers experimented using mobile devices for the creation of an expert system-based context-aware ubiquitous learning, which proved effective in perceived usefulness (Wu et al. 2013). However, we still need to see the value of SGs in u-learning for both students and teachers.

There are a number of frameworks identified for SLEs implementations (Gao et al. 2019; Hwang 2014; Liu and Hwang 2010). The guiding values provide by Liu and Hwang (2010) of "immediacy", "inquiry learning", "collaborative learning", "guided learning", "assessment by sensors", "facilitating learning skills" and "facilitating social skills" form the basis of our inquiry into the SGs for u-teaching. Immediacy refers to the intuitive ways for giving timely feedback to students, e.g. using SGs, a teacher can analyse the student performance analytics (Locklear 2018; Wells 2014). "Inquiry learning" refers to the knowledge construction through interactions with the real world thus developing a personalised learning style. For example, using SGs, the instructors would know the set of questions asked by specific students and can gauge their personalised efforts towards learning (Locklear 2018; Wells 2014). "Collaborative learning" refers to learning which results from teamwork through distributed cognition involvement. SGs can help keep the records updated in real-time, whether between group members or parents-teachers or student-teachers. "Guided learning" refers to the exploration of different learning styles. The use of SGs can help in keeping a real-time log of what went right and what went wrong so that the next time, more time is spent on improving the teaching style. "Assessment by sensors" is core to SGs. These glasses take contextual information through different sensors. The last two guiding values of "facilitating learning" and "facilitating social skills" come as the by-product using SGs in u-learning settings.

2.3 Potential of Smart Glasses

Taking the above-mentioned benefits of SGs further, they can possibly become an extension of human body and mind as they are known to enhance the interaction of human cognition with the environment, which can sense the surroundings to perform various tasks of communication and collaboration (Hofmann et al. 2017; Locklear 2018). They can help in remembering and recognising objects and can essentially block unpleasant experiences and avoid anxiety.

They are used in augmenting text with videos and animations to make students learn new vocabulary (Hofmann et al. 2017). For instance, in trying to learn a new word, a student could see an overlayed image of the object the word stands for. These techniques also compensate for any other impaired functions such as for slightly visually impaired can see an enhanced version of landmarks for moving around easily (Peddie 2017).

In classes involving anatomy and technical drawing, augmented reality was used to create interactive views of 3D models that were based on the 2D imagery in textbooks. It was also used for a class that involved exploration and discovery. This happened when they were visiting a museum to learn about history (Arnhem and Spiller 2013; Hobbs et al. 2016), music and mathematic classes which involved a lot of visual concepts such as graphs and special geometry were also using the technology (Sommerauer and Mueller 2018). Conferences relating to surgical education (Atherton et al. 2013) and astrophysics (Vogt and Shingles 2013) used it to improve communication in the posters section. Audiences could see more information overlayed on the posters and this made it easier to understand the technical work.

SGs found early adoption in the field of medicine. Early work in the field of paediatric surgery tested SGs' applicability in their domain and concluded that there were definitely some useful applications such as being able to photo and video-document, search for unfamiliar medical terms on the Internet, and being hands-free. However, they pointed out that specialized medical applications had to be developed for the device to maximize its usefulness (Tilo et al. 2016).

2.4 Content Creation Technologies

Currently the Learning Management Systems (LMSs) such as Moodle, Sakai, and Blackboard, etc. have been supporting the teachers in creating, designing, administering the delivering online courses (Graf et al. 2010; Kumar 2019; Ros et al. 2015). These systems can provide the same study materials to every learner. The main difference between the adaptive learning systems (ALSs) and LMSs is that the latter strives to consider the individual needs of the students. These needs could be students' prior knowledge, learning styles, cognitive abilities, motivations, and interests, etc. It is established that ALSs, though is beneficial for students, is not as easy to adopt by the teachers, because they put overhead on content delivery (Graf et al. 2010) and develop an extension of LMSs. Taking this information further, in this paper, we examine the content-creation tools available in the market for SGs. This helps us in recommending the most suitable to adopt by the teachers. This is done by comparing the existing frameworks that are popularly used and then evaluating one of them to be the most suitable. The comparison was made based on the factors which make the teachers choose certain technology in their classrooms.

Most of the previous studies done are based on the Technology Acceptance Model (TAM) and they have used the same constructs of Perceived Functionality (PF), Perceived System Support (PSS), Perceived Usefulness (PU), Perceived User-Interface Design (PUID), Perceived Ease of Use (PEOU), and Perceived Self-Efficacy (PSE) (Fathema et al. 2015; Ros et al. 2015).

1. The application design should have a web-based interface that can be used in browsers. The interface should be "easy-to-use." That means it should have intuitive drag and drop capability to create content (Aldunate and Nussbaum 2013) (PEOU).
2. The application design is significant in adopting technology (Ros et al. 2015) (PUID).
3. The framework must be compatible with SGs or wearable headset technologies (PF).
4. The framework should be updated regularly with new features or content (PSS).
5. The framework should have value for money, to acquire higher authority commitment (Zheng et al. 2019).

The above literature review helps in conceptualising an interaction model to use smart glasses.

3 CONCEPTUAL MODEL FOR THE USE OF SMART GLASSES IN U-TEACHING

This paper presents the conceptual model (Figure 2) for the use of SGs in education adapted from the experienced-based collaborative service system model (Atiq et al. 2017). The strength of this model is that it combines service-dominant logic (Vargo and Lusch 2004) and value creation models (Grönroos 2012) from marketing literature and metamodel (Alter 2011) from information systems literature for technology-enabled interactions. Only the shaded cells in the conceptual model are discussed in this paper. This paper is looking at the use of SGs from the perspective of instructors. This conceptual model will be empirically analysed in an education environment in future research.

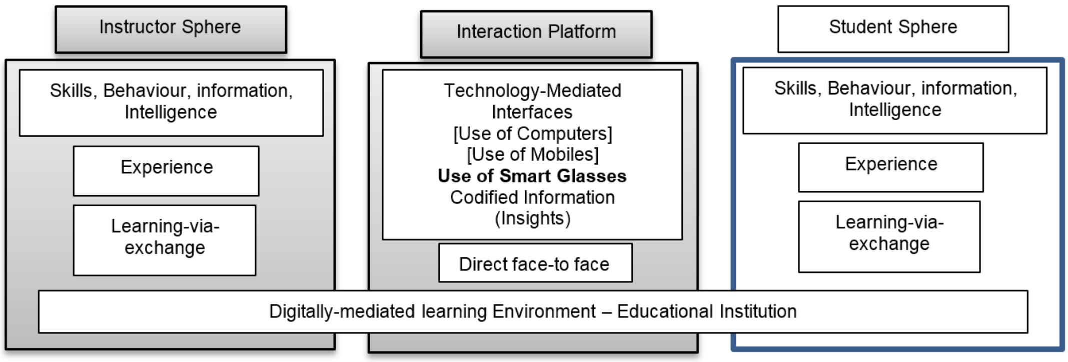

Figure 2: Conceptual Model for the use of Smart Glasses in Education adapted from Atiq et al. 2017

3.1 Interaction Platform

The use of SGs is powerful as it gives a personalised interaction, and also lets the instructor evaluate the students' performance in real-time. In the age of technology, where students can find learning material online, the teachers can stay ahead by reducing that information overload for students and scoping up efficiently what is already on the Internet for them to learn better. With SGs the classes can be taken anywhere, e.g. a geography class can be take outdoors e.g. mountains where students are learning about stones. Likewise, if the students can't be taken, then through AR technologies, the SGs can be used to make the students learn the same stones in the classrooms. In literature, it has been agreed that mediated technologies attract the attention of learners and enrich the thought processes. There is a large body of research done on the DML environments which are constantly improving with the advances in the mediation tools. Though, how quickly and efficiently the instructors make use of these tools is yet to be seen, as it will help to create an efficient learning environment.

3.2 Instructor Sphere

The constructs necessary for the interaction by the instructors in a DML environment are extracted from literature. The technology-driven and early innovators are the ones with positive attitudes to adopt technology in their classes. Hence, skills and behaviour are important aspects in the instructor's sphere, along with with their knowledge, and intelligence; the tacit knowledge gained through their experience and through constant learning-via-exchange. In this scenario, one of the needed skills to make lecture materials is to know, which one and then how to use those content-creation frameworks available in the market for SGs. From prior research, we can safely conclude that initially an extension to LMSs would be required (Graf et al. 2010). As depicted in Figure 1, content-creation falls within SGs and teacher interaction.

3.2.1 Content - Creation frameworks Suitable for SGs

Table 1 compares these frameworks. The frameworks are chosen for comparison based on their popularity: Wikitude, Layar, Metaio, Augment, Aurasma (Figueiredo et al. 2013). The factors are coming from factors extracted in section 2.4. The result is plausible with the results of Figuieiredo et. al (2013).

We found that Aurasma and Wikitude have the highest availability of features with four out of the five features being available. However, not all features have the same weightings. We argue that it is more important for the software to be easy to use than it is for it to be free. To support this argument, we point out the use of the Microsoft PowerPoint tool to create presentations. Even though it has associated cost, it's easy to use interface made it quite popular compared to some free software that are complex to use. Therefore, we recommend Aurasma to be the most suitable implementation framework based on the following comparison.

Factors for technology adoption by teachers	Application Frameworks				
	Wikitude	Layar	Metaio	Augment	Aurasma
1.Requires knowledge of programming language (PEOU)	Y	N	Y	Y	N
2. Stand alone	Y	Y	Y	N	Y
3. Compatibility (PSS)	Y	N	N	N	Y
4. Updates (PSS)	Y	Y	Y	Y	Y
5. Value for money- (Free to Use)	Y	Y	Y	Y	N

Table 1: A comparison of implementation frameworks based on the factors listed in the previous section. (Y represents that the feature is available. N represents that the feature is not available for that framework.)

Anyone should be able to use it on any browser, even if they are not skilled at programming. Standalone has the benefit of easy installation or access; users who would otherwise be dissuaded by complex installations could use the framework. The framework must have the support for SGs otherwise the content would be limited to mobile phones and tablets. Updates are necessary because new features and content keep the users engaged and encourages them to create new content. If it is free or has some value for money, then the institutions would adopt it willingly.

4 DISCUSSION

In university settings, the use of PowerPoint presentations is prevalent. SGs can potentially increase the engagement of teachers with the students. Students who are shy can ask questions only with the teacher, without putting themselves in a hot spot and teachers would know how they should respond to the whole class without any disruptions to the lectures. The teachers would know in a class of hundred, the names of all the students, their analytics for the class; how many questions they ask? What issues do they face? etc. These are some of the many benefits SGs could provide.

The development of specialized applications has been key to the success of SGs in certain industries such as medicine and automotive. Such development is not seen in education. Therefore, a suitable development framework in education is needed which could be an extension of the current LMSs.

From literature, we can imply that the technology works well when there is a need for a hands-free experience, or when the use of augmented reality (AR) is conducive to the task at hand. Therefore, if SG is to help set up a DML environment, then it should attempt to satisfy either or both conditions i.e. hands-free and the use of AR. There are some areas in learning which would involve both conditions. For instance, physical education, art and design disciplines would be the areas that intuitively receive help from smart learning. However, it is not entirely clear how other areas that may be more theoretical in nature, would benefit from SGs.

The reason for this lack of clarity is attributed to the fact that the current SLEs are built on old pedagogies and old learning and assessment strategies that are unsuitable for an SLE. As such, a suitable pedagogy framework and a suitable implementation framework must help with the development of the DML environment.

The pedagogy refers to the practice and method of teaching. It includes assessment paradigms, learning paradigms, policy and social factors (Almarzooqi 2019). From a pedagogical standpoint, mediated reality works well with the existing learning theories. It does so by placing a learner in a specific context. The learner is then given active learning opportunities that are self-directed. Additionally, the information is represented in multiple modes (Chen et al. 2017).

Therefore, the paper recommends the following elements that would make for a suitable pedagogy that uses SGs to create a DML environment.

1. Animated content in the classroom. Any content that was traditionally shown in 2D space should be shown in 3D space using AR.
2. Personalized content for a student (additional concepts and content can be overlayed on existing content for students who need it). For instance, one student may have diverse needs from another and therefore needs more annotation and context along with the main content. Using AR, this extra content could easily be shown to those students who need it, without affecting other students.
3. New assessment strategies that document the process and not just the result. So far, the trend for assessments has been to focus on the result which means that the final submission could have been done by anyone. However, if SGs were used, then it allows for hands-free documentation to take place while the student is creating content. Therefore, it would be easy to show the author of the work.

Having a suitable pedagogy alone is not enough for a digitally enhanced learning environment that uses AR because creating such content would require advanced technical skills and specialized knowledge. Therefore, for wide adoption of AR learning activities among educators, they should have access to authoring tools that are intuitive, easy to use, do not require programming skills, and are provided to them.

5 CONCLUSION

To use SGs in a learning environment, suitable pedagogy schemes and implementation frameworks are needed. This paper presented a conceptual model through which the digitally enhanced learning environment specifically using SGs can be offered to teachers. The paper discusses the available applications which can help in content creation for SGs. Aurasma was found to be the most suitable framework based on several factors which included ease-of-use, cost, and availability, among others for creating AR-enabled teaching content.

A practical pedagogy would include new assessment strategies, a classroom where content is delivered in 3D space complementing or replacing the traditional 2D space of a whiteboard or presentation screen. Additionally, it would include SGs for easy documentation and have the potential to shift some focus on to the process, and delivery of courses, among several other features. Therefore, if the recommended framework and pedagogy are adopted, then it would improve the learning environment. However, there is a concern with privacy, misuse and social acceptance due to the pervasive nature of AR.

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