

# The Applications of Augmented Reality Technologies in Mathematics Education

Mehryar Nooriafshar  
[mehryar@usq.edu.au](mailto:mehryar@usq.edu.au)

*University of Southern Queensland, Toowoomba  
Australia*

Darius Nooriafshar  
[w0100130@umail.usq.edu.au](mailto:w0100130@umail.usq.edu.au)

*COMTEL, Australia*

## **Abstract**

Recent research in the area of multimedia conducted by the authors in Australia, Japan and North America has re-confirmed the importance and effectiveness of visual features in teaching and learning materials. According to the findings, the visual aspects and interaction with the multimedia systems are the most preferred features amongst the surveyed students. In all of these studies, the surveyed students have also indicated that the visual features play a very important role in understanding the concepts. Based on these findings, the authors have embarked on an investigation to determine the practical and innovative uses of the technologies associated with augmented reality. A very typical augmented reality product is Google Glass. Hence, this paper has initiated a study on the possible contributions this amazing device can make to mathematics education. It has been shown that Google Glass can assist learners to access and share information, connect and engage in discussions with others by utilising a more human-like interface.

**Key words:** Google Glass, Augmented Reality, Mathematics, Education

## **Problem Statement and Purpose**

Google is about to introduce “Google Glass”. This device is described as a wearable computer which, in a hands-free manner, allows the wearer to access the Internet and utilize the incorporated 720p camera. The camera, a prominent feature, can capture both still shots and video clips for storage or sharing purposes. The most important feature of Google Glass (The Glass) is that the user has the option of providing the commands without, practically, lifting a finger. In other words, the interface with this wearable computer is more natural and human-like. This feature can be referred to as bringing the technology closer to human senses.

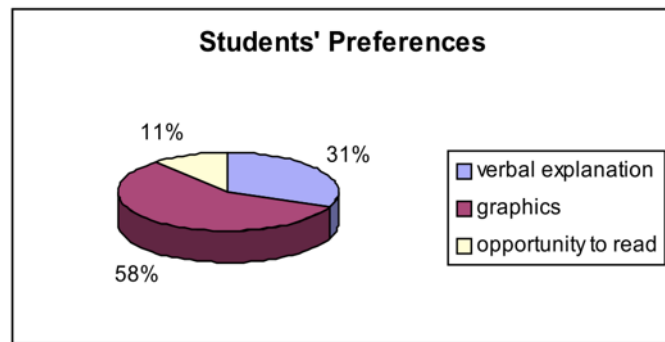
The Glass will be available to purchase in 2014. Its anticipated price may be \$1000-1500. There have been some indications of a lower price too. This device will

certainly have a very promising potential in learning as it can revolutionise digital education. Its uses will transcend many existing digital products used in education.

Based on several years of research in the use of technology in education, the author foresees very interesting and practical learning and teaching applications for the Glass. The purpose of this paper is to explore and identify possible innovative educational applications of this amazing development.

### Research Background

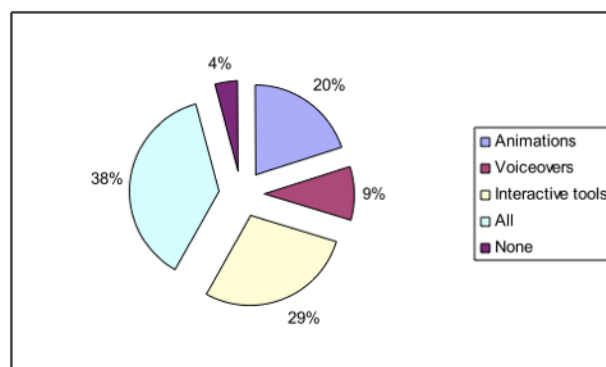
According to a survey by the author in 2002, it was discovered that most (about 58%) of High School students in the Darling Downs region of Queensland, Australia have a preference for visual learning with regard to quantitative topics. See Figure 1.



**Figure 1** – Students' Preferences for Different Types of Media

High School Preferences for

Further research and studies in the area of multimedia by the author and his colleagues have re-confirmed the importance and effectiveness of visual features in teaching and learning materials (Nooriafshar and Todhunter, 2004). Figure 2 illustrates the students' learning modal preferences with regard to *Web Enhanced Multimedia Learning Environment (WEMLE)*. This learning environment is a visually rich multimedia system which was used as an instrument in the study. As Figure 2 shows the visual features and interaction with WEMLE appear to be the most popular amongst the 100 surveyed undergraduate and postgraduate students.



## **Figure 2 – Tertiary Students' Preferences for Different Types of Media**

A recent investigation by the author on three groups of students from Australia, Japan and Canada indicated the effectiveness of visually enhanced multimedia approach in education (Nooriafshar, 2013). The investigation with every group included a presentation of the Project Management fundamentals using the specially developed multimedia system and a specially developed workshop. The workshop consisted of a test case study which was used as an instrument to gauge the learning effectiveness. Based on the students' performance in the test case study, it was established that the specially designed visually rich multimedia system had potential for effectively learning of the fundamentals of Project management.

### **Experiments with the Very Latest Technologies**

Teaching mathematics, generally, involves step by step demonstration of the necessary procedures.

The mathematics topics to be taught can range from simple arithmetic operations to more complex algebra. Regardless of the complexity of the topic, they all share the common teaching aspect of systematic demonstration of the procedures. Traditionally, the teaching has taken place either in a classroom or on an one to one basis.

Due to the nature of the subject, the mathematics teacher would usually show the learners the necessary steps in a sequential manner. The teacher would also often complement the visual aspect (symbols, numbers, etc.) with oral explanation. Hence, the learner can easily relate to the sequence of procedures.

This method of teaching mathematics is, usually, a two way process. That is to say that the teacher goes through the steps and the student also, in asking or answering questions, follows a similar step by step process. Hence, the visual aspect of the entire process is quite important. In a classroom environment, the face-to-face contact aspect allows the teacher and learner follow the steps required in teaching and learning mathematical processes. This aspect can be recorded in some form and be provided to learners outside the classroom. Hence, a learner can access a simulation of the classroom teaching at their own pace. The progress in the technologies associated with the modern computers have been ideal in recording, storing, distributing and playing back teaching materials. For a typical example, see the Algebra video clips on the Khan Academy' website (KhanAcademy, 2014).

This paper explores the potential uses of the very latest developments and technologies associated with the enhanced visual features. One of these latest developments is Google Glass. Google Glass is a typical Augmented Reality (AR) device. It is expected that the AR technology will capture a very large (several billion dollars), portion of the market in the near future (Hyman, 2013). This device will have

a great deal of applications in several areas. The device's visual capabilities are, probably, amongst its strongest features. The main reason is due to the fact that this technology intends to bring the computing closer to human senses. For instance, the embedded screen will be only a few millimeters away from the human eye. Additionally, the user does not have to lose concentration on performing or examining a task when looking at the screen. One can still see the job at hand and view the screen at the same time. Therefore, recording a scene or action and performing a task can be, simultaneously, carried out.

It should be noted that a similar approach, to a certain extent, can also be adopted by using a device such as iPad. This particular tablet is complemented with Apple's numerous and ever increasing apps on iTunes. One of these apps which has been put to the test for its strengths in visual aspects is Scribbie (Supreme Heaven Internet Team, 2012). Although this product on iPad is not a wearable device as in an AR glass, it, to a certain extent, simulates face to face teaching of a mathematical procedure. The visual aspect can be also complemented with relevant audio and the learner can view issues with enhanced visuals. As suggested by Lee (2012), AR technology has the potential to engage and motivate learners in a totally different way which has not been implemented in the real world. Hence, this particular iPad app exhibits some of the main features of AR.

Other technologies such as Virtual Reality (VR) will allow the learners to be a part of the learning materials and play a key role in the learning process.

Although the term Virtual Reality (VR) is used for different purposes, the original concept refers to *immersive virtual reality*. The general concept of immersive virtual reality was developed back in the late 80s. In immersive virtual reality, participants interact with a world completely generated by computer which is a virtual replica of the actual subject.

As suggested by Beier (2004), one of the main characteristics of immersive virtual reality is that the environment is a full scale replica of the real world and it relates to human size. Hence, the participants get the feeling as if they are interacting with the real environment or subject.

Let us investigate how a VR multimedia can be implemented and used in language education. The learners will be provided with VR goggles, gloves and shoes. The gloves and shoes can be in the form of micro-sensors placed in appropriate body parts for input/output and interaction purposes. After wearing and attaching the goggles and the sensors, the learners will visualise, feel and hear themselves in an actual location. For instance, they can, virtually, be in front of the *Plaza de toros* in Madrid. They can physically (in a virtual manner) approach a virtual local and virtually ask by moving their hands and arms and their usual facial expression (smile, worried and desperate) *Dónde está la Stacion de taxis por favor?* The local pedestrian will smile back in recognition and encourage a foreigner trying to speak their language and point to the right corner. This scenario can be extended

into a see, hear, touch and walk adventure too. Imagine entering a virtual shop and virtually touching and picking an object and asking *Cuánto cuesta* (How much)?

It is noteworthy to mention that the technology involved and required for the VR educational multimedia approach as described above is not an impossibility in an almost near-future. Although it is not possible to set up the above-mentioned experiment right now, it is reasonable to predict superior results as several senses will be utilised. We know that for thousands of years, human beings have acquired and processed information using a number of different senses. Hence, the use of different senses for information collection, analysis and remembering is something, which our brain can relate to very well. The introduction of Google Glass (Late 2013) is certainly a “giant step” towards realizing this scenario. Google Glass, to a large extent, can achieve the realisation of the above experiment. The next section discusses the main features and ways of using Google Glass.

### **Main Features and Methods of Using Google Glass**

Google Glass or the Glass has been described as a computer which can be worn like glasses. The Glass is designed in such a way that it offers hands-free operation features. The wearer can interface and communicate with the Glass by voice commands. Usually a tilt of the head to a side and issuing the command “OK Glass” followed by the request prompts the device to act. Its potential uses, however, go beyond a hands free computer. It practically addresses the interface problem between human and machine. The tap, touch and pinch way of interfacing with computers in modern smart phones/tablets has certainly been a significant contribution to this problem in recent years. Back in the early 1980s, Edward Feigenbaum (founder of the Knowledge Systems Laboratory at Stanford University) described the keyboard as an unnatural way of interfacing with computers (see Nooriafshar, 1995). He also predicted that by the end of the previous century the keyboard way of communicating with computers would be phased out. His prediction was probably something close to having a "natural" and more intelligent dialogue between humans and machines. Although this prediction was not quite realised by then, many advances through intelligent voice recognition approaches such as Apple’s SIRI have been achieved.

Google Glass, in addition to being a new idea or discovery, it is also a new way of thinking. Hence, the concept is quite compatible with the quote by Szent-Gyorgyi (1962): “Discovery consists of seeing what everybody has seen and thinking what nobody has thought.” The most important aspect of the Google class is the way it facilitates a totally hands free and more natural interaction with the technology. In terms of the technological features, it should be noted that currently most of the smartphones and tablets are in possession of them.

After testing the Beta version of the Glass, Topolsky (2013) suggested that it is a completely new kind of computing device, designed to reduce distraction and created to enable humans to interact and communicate with the technology in a natural manner. One of the logical arguments in favour of the Glass is that when we all are

trying to take photographs or videos of important events such as a child's performance at sporting activities, we are distracted from seeing the real-life situation at the same time. With the Glass, however, the user can enjoy the real scenery and at the same time capture images. The action is performed hands-free without using any buttons, adjusting anything or looking at or through the viewfinder or lens.

Google Glass with its augmented reality features will facilitate a forward-looking approach to education. This device will have tremendous potential in education. For instance students can wear these glasses and by looking at topics in the classroom, they can find the right answers from the Internet without hunching over the handheld devices. Students can read a book and at the same time give commands to Google Glass. They can take notes; take pictures of the relevant diagrams, charts and images. If they are not sure about something (topic, definition or terminology), they can simply find out by asking Google glass to search the Internet. Even capturing video/audio of the relevant parts of the lecture or presentation would be quiet useful for the future reference. They also interact with each other when necessary.

Google Glass is only the beginning of bringing the technology closer to the human senses. Future information technology products may also facilitate capturing, digitising, storing and transferring human thoughts as an independent medium directly to other sources. Imagine the ability of directly transferring an animation of a concept to a learner in a 'thought file'. After all, the language of thought is probably universal and is not based on a particular type of language. In a strictly natural way, we do not have to pronounce words in our thoughts to describe ideas. Our ideas can be “seen” in our thoughts. Perhaps these images are like Plato's Forms (*Plato's Republic*) or Aristotles' Essences (*De-Anima*).

In this way, most of the language-dependent barriers will be removed and we will achieve that ultimate level of internationalised information transfer and sharing.

### **Conclusions**

It was reported that visually rich multimedia can provide a very effective teaching and learning environment. A virtual reality multimedia can even further enhance learning by incorporating more realistic images and visual features. This progress will lead to a situation where the learners could immerse themselves in the environment and interact with objects and scenarios in a dynamic manner.

The future technologies will enable us to interact with computers in a less formal manner. In other words, we will not have to sit in front of a computer, switch it on and then start typing and mouse-clicking. The main computer will be able to receive commands and requests remotely and produce output to various locations around us. The output can even be in the form of holographic images and sound. The speech will be controlled by the user. Hence, the user can choose any language for input or output. The user will be able to interact with the output in a natural manner by touching, separating, lifting and moving parts. Hence, a true virtual reality situation

will be created. A development such as Google Glass is definitely the beginning of this exciting journey which will impact education in many ways. It is envisaged that as soon as the Glass is available, the author will test its educational potential as suggested in this article.

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