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Augmented Reality in E-Learning - Review of Prototype Designs for Usability Evaluation

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Abstract: ***The concept of e-learning has reached beyond use of PowerPoint presentations and audio-visual contents. After virtual reality (VR), augmented reality (AR) based systems are preferred to support teaching and learning activities along with these e-learning systems. As an emerging technology, AR has become a point of interest for researchers in education field. So this paper will review some of the prototypes developed for educational purposes and compare their usability for finding benefits of AR. It also focuses on use of web 2.0 tools along with AR in educational environments.***
Keywords: Augmented Reality; e-learning; usability; web 2.0.

I. INTRODUCTION

Educational globalization and advanced economy has brought essential changes at individual dimension, just as corporate dimension; the improvement of innovations and the enhancement of access to them produced speedy changes at the dimension of human recognition, growing new needs and individual abilities for testing. The most recent decade, through the globalization of the advanced business condition has created new individual propensities with respect to requirements for utilization, acknowledged types of introduction and acquiring of items in the computerized condition, consequently building up a dimension of computerized immersion which would already be able to be incorporated to the conventional class; surpassing this dimension was activated and dependent on the expansion of human limit of seeing the truth, helped by a satisfactory innovative foundation. From this viewpoint, at worldwide dimension, the 60s propelled another test opening another way, that of enlarged reality (AR), and incommensurable conceivable outcomes for utilizing its applications in every one of the regions of financial movement. From that point forward, augmented reality had combined as innovation, fusing complex applications and frameworks in an ever increasing number of fields of the worldwide economy; the quick development of cell phones and the virtualization of the advanced condition have arranged a promising domain for huge usage of AR arrangements at worldwide dimension.

In this unique circumstance, augmented reality, with virtual reality can offer essential help arrangements in demonstrating this present reality with the point of expanding the human capacities of observation, permitting the opening of another stage on the planet's financial improvement.[3] Augmented Reality can be connected for learning, stimulation, or edutainment by improving a client's impression of and association with this present reality. Students can move around the three-dimensional virtual picture and view it from any vantage point, much the same as a genuine item. The data passed on by the virtual items enables clients to perform genuine assignments. Tangible Interface Metaphor is one of the vital approaches to enhance learning. This property empowers control of three-dimensional virtual articles just by moving genuine cards without mouse or console. Augmented Reality can likewise be utilized to upgrade collective undertakings. It is conceivable to create imaginative PC interfaces that blend virtual and genuine universes to improve eye to eye and remote coordinated effort. These augmented reality applications are progressively like characteristic vis-à-vis coordinated effort than to screen based cooperation. Web innovations and internet are mainstream, as a down to earth circumstance individuals still favor perusing books as opposed to confronting screens and course readings are still generally utilized. Another fascinating utilization of this innovation is in augmented reality reading material. These books are printed ordinarily however indicate a webcam the book brings perceptions and communications structured. This is conceivable by introducing uncommon programming on a PC, utilizing unique portable applications or a site. This innovation enables any current book to be created into an increased reality release after distribution. Utilizing 3D items and sees, random and creative media, reproductions with various sorts of collaborations is the least demanding methods for associating the two disengaged universes. Using Augmented Reality in printed book pages, course books will end up unique wellsprings of data. Along these lines individuals with no PC foundation can even now have a rich intelligent ordeal.[2]

The purpose of this review is to find how much of AR's benefits are applied with e-learning systems. The primary objectives of this survey are:

1) Usability evaluation of AR based systems and benefits they achieved.
2) Finding usability of AR along with web 2.0 tools in educational systems

II. BACKGROUND

A. Augmented Reality

Azuma et. al.[1] characterizes AR as 3-D virtual articles are coordinated into a 3-D genuine condition progressively. So the essential prerequisites of AR are:

It requires the mix of virtual components and genuine condition.

It requires three-dimensional enlistment with the end goal that the virtual components are adjusted to the genuine condition.

It requires is ongoing intelligence with the virtual components. In this way, the virtual components must act like a genuine component in the genuine condition. This may mean, however isn't constrained to, the AR framework reacting to changes in the point of view of the client, changes in lighting conditions, impediment and other physical laws.

B. Augmented Reality Learning Experiences

The Augmented Reality, as a cutting edge interface, bears an alternate method for connection with data. This cooperation can be utilized to configuration better learning encounters. We characterize the term Augmented Reality Learning Experiences (ARLEs) to allude to learning encounters encouraged by AR innovation. A few instances of ARLEs for different subjects resemble material science, science, topography and arithmetic, just as, instructive amusements for essential training. Beside these substance, ARLEs can be utilized for space science, science, geometry and social legacy. These sorts of substance rely upon the capacities of AR to:

1) Illustrate spatial and temporal concepts.
2) emphasize relationships between real and virtual objects.
3) provide intuitive interaction.
4) visualize and interact in 3D

C. AR Affordances and Benefits

The analysts structured their ARLE to exploit the affordances of AR innovation. These affordances are gotten from the very idea of AR: the ongoing reconciliation of virtual components to a genuine situation. By the definition, augmented reality bears:

1) *Genuine Explanation:* To show content and different images on true articles.
2) *Relevant Perception:* To show virtual substance in a particular setting
3) *Vision-haptic Portrayal:* To engaged embodied collaborations with virtual substance. Aside from the common affordances of AR, structure systems have been connected to the formation of progressively viable ARLEs. In ARLEs, specialists have utilized the accompanying procedures:
4) *Empower Investigation:* planning AR content that is non-straight and energizes further examination.
5) *Advance Coordinated Effort:* Structuring AR content that expects understudies to trade thoughts.
6) *Guarantee Inundation:* Structuring AR content that enables understudies to focus more and be locked in at a steady dimension.

III. LITERATURE REVIEW

A. About AR

As per Azuma et.al.[1] Augmented Reality innovation is anything but another issue. It has been utilized in fields, for example, military, medication, building plan, automated, tele-mechanical, assembling, upkeep and fix applications, shopper structure, mental medicines, and so on. The creators have considered the advantages of innovation in different fields.

B. About AR and Web2.0 in Education

As AR can be utilized for instruction, countless have been created for instructive settings. Different such articles distributed in diaries and meeting procedures are looked into for choosing the adequacy of AR in instruction. The innovation is generally utilized alongside e-learning frameworks and handheld gadgets. Additionally, articles which portray utilization of AR and web2.0 are studied.

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IV. METHODS

A. *Meta-Analysis*

We directed an orderly writing survey dependent on crafted by Ericson et al. [4]. Their meta-examination expected to quantify the effect of ARLEs in K-12 (pre-school, grade school, and secondary school) instructive settings. Their examination of 503 articles demonstrate that the impacts related with innovation have not changed significantly throughout the years. The mean impact size of innovation connected to instruction watched is 0.56 or low to direct impact.

The approach for the methodical writing survey is as per the following:

1) *Search for Prototypes:* A writing look was led in year 2013-2014, distributed in IEEE Xplore Digital Library, Science Direct, Springer, and Elseveir and so forth. The inquiry is restricted to diary articles and meeting procedures that are written in English.

2) *Inclusion Criteria:* The substance important to instructive applications and for the most part concentrating on advanced education was considered for this study. Consequently, for the exploration paper to be incorporated, the accompanying criteria must be met

a) The examination paper must have something like a starter working ARLE model.

b) The model ought to be connected to learning another idea or ability.

c) The substance ought to be applicable to auxiliary or advanced education.

d) The paper reports an impact measure or gave a way to ascertain the impact estimate (reports both mean and standard deviation).

Applying these criteria resulted in 4 articles.

3) *Data Gathering:* We computed the effect size (d) using formula: $d= (x_e - x_c)/s$ (1)

Where, $x_e$is the mean of experimental treatment that using AR and $x_c$is the mean of control and s is pooled standard deviation obtained as: $s=(s_e + s_c)/2$ (2)

Where $s_e$is standard deviation of experimental treatment and $s_c$is the standard deviation. We interpret the calculated effect size based on Cohen's recommendation, that is, an effect size of 0.8 or higher is considered large, around 0.5 is considered moderate, and around 0.2 is considered small.

B. *Qualitative Analysis*

1) *The Search for Prototypes:* Search for prototypes was carried out in the same way as in meta analysis. The articles considered for meta analysis are also included for qualitative analysis

2) *Inclusion Criteria:* For inclusion in qualitative analysis, we focused on the evaluation technique and benefits achieved. So, the criterion for effect size was relaxed.

3) *Data Gathering:* A survey questionnaire was drafted to facilitate the gathering of data from the 10 included articles. The questionnaire has four main parts namely: publication details, prototype description, use of AR, design and results of the user .

V. RESULTS AND DISCUSSION

A. *Meta-Analysis Results*

There were four articles which reported their values of experimental evaluation. The AR applications used for education and their effect sizes are summarized in Table 1.The mean effect size obtained is 0.511 which is moderate.

TABLE I. Summary of prototype experimental evaluation and effect size

Ref	content	Participant	Control group	Exp. group	effect
[6]	Game of Go	18 volunteers (age:21-32)	PC based ‘Go’ game learning	AR based ‘ARGo’ game	0.232

[10]	Interacti ve agent	15 students (age:8-13)	Collaborativ e learning environment	AR based interactive agent to speak	0.525
[11]	OOP course	200 students	e-learning approach using LMS	AR based course content	0.8
[12]	English language course	6 classes	Text based audio-visual data	AR based immersive e-learning	0.486

B. Qualitative Analysis

We selected ten articles having educational prototypes according to given inclusion criteria. The usability of AR in education is mostly evaluated using survey questionnaires and personal or group interview methods. Some researchers have used combination of such data collection methods. The prototype descriptions and tools described in each article are summarized in Table 2.

TABLE II. Summary of Preliminary Studies Using Survey tools

Ref.	Year	Prototype Description	Tools
[5]	2011	AR based 3D digital media teaching materials for teaching Physical Science	Triangulation-combined evaluation using interview, observation, questionnaire
[6]	2011	A game of GO, for self learning	Questionnaire based on IMI, result based on Lickert scale
[7]	2011	2D and 3D models for learning computer graphics(I/O devices)	Group interview
[8]	2012	AR for architectural visualization	Own questionnaire, result based on Lickert scale
[9]	2012	Cultural and natural heritage	Feedback Survey
[10]	2012	Interactive flower garden with interactive agent in augmented picture	Observation, result based on Lickert scale
[11]	2013	Mobile software to support learning experience for OOP	Own questionnaire, result based on Lickert scale
[12]	2011	Authoring tool for e-learning applications	Experimental evaluation using observation
[13]	2011	Game base introduction to programming	Feedback Survey
[14]	2009	Interactive learning system for conservation of fish	SUS questionnaire result based on Lickert scale

Most articles reported have used questionnaires and evaluated results based on Lickert scale. [2] has used questionnaire based on IMI that is the researchers used a part of the Intrinsic Motivation Inventory (IMI) to analyze four subscales: enjoyment, competence, usefulness, and tension.

There are various ways of using AR technology like marker based AR, AR for projection, AR for GPS based system. For educational setting mostly used is marker AR. The affordances of AR technology implied in the prototype and the other pedagogical benefits achieved are summarized in following Table 3.

TABLE III. Summary of AR affordances and benefits achieved

Ref	Type of AR technique used	AR Affordances	Benefits achieved
[5]	Marker AR for 3D material and objects	Real world annotations	Ubiquitous learning environment
[6]	Augmentation of 'Go' game board	Contextual visualization	Self learning support
[7]	3D models using 3DMax and AR Plug-in	Contextual visualization	Collaborative and Interactive learning
[8]	Marker AR for architectural project	Real world annotation	Student satisfaction
[9]	AR using Hoppala and Layar tools	Contextual visualization	Collaborative and immersive learning
[10]	Marker AR for augmentation in picture	Contextual visualization	Increased engagement in learning
[11]	Marker AR to play video and enable AR sessions	Real world annotation	Increased engagement and enjoyment
[12]	Marker based tool for creating e-learning content	Vision haptic visualization	Increased academic achievement
[13]	QRcodes for augmentation of game board	Real world annotation	Increased engagement in learning
[14]	Marker AR for 3D virtual models for fish	Real world annotation	Increased enjoyment in learning, positive usability

Most researches have proved that their prototypes using AR have three inherent affordances as Real world annotations, Contextual visualization, and Vision haptic visualization. So the benefits achieved include collaboration support, increased enjoyment, engagement in learning etc. The articles have reported the positive usability of AR technology. But experimental evaluation of systems developed is also necessary for effect size calculations.

C. Web 2.0 along with AR

Web 2.0 technology has support for collaboration, social interaction, creative thinking of students in e-learning environments. Some researchers have developed to use benefits of both AR and web 2.0. Hong et.al[15] have developed a system which uses Wearable device with AR interface to share Social network information.

Benefits

1) In medical Training

a) Laparoscopic surgery

b) Endotracheal intubation

c) Joint injections

d) Assistance in placing local anesthesia

2) In Chemical Education

a) 3D visualization of molecules, their spatial dynamics and interaction, possibility to form molecules from individual fragments.

b) 3D visualization of molecules and crystal lattices

3) In Computer Graphics

a) 3D modelling of graphics

VI. CONCLUSION

We have studied the educational prototypes for their effect size and benefits achieved by them. Combination of AR and web2.0 technologies can give better results in educational achievements. AR increases engagement, immersion and web 2.0 supports collaboration, social interaction. These technologies have been studied separately for benefits in learning systems. Therefore both technologies should be studied for experimental evaluation of their combined use in educational settings.

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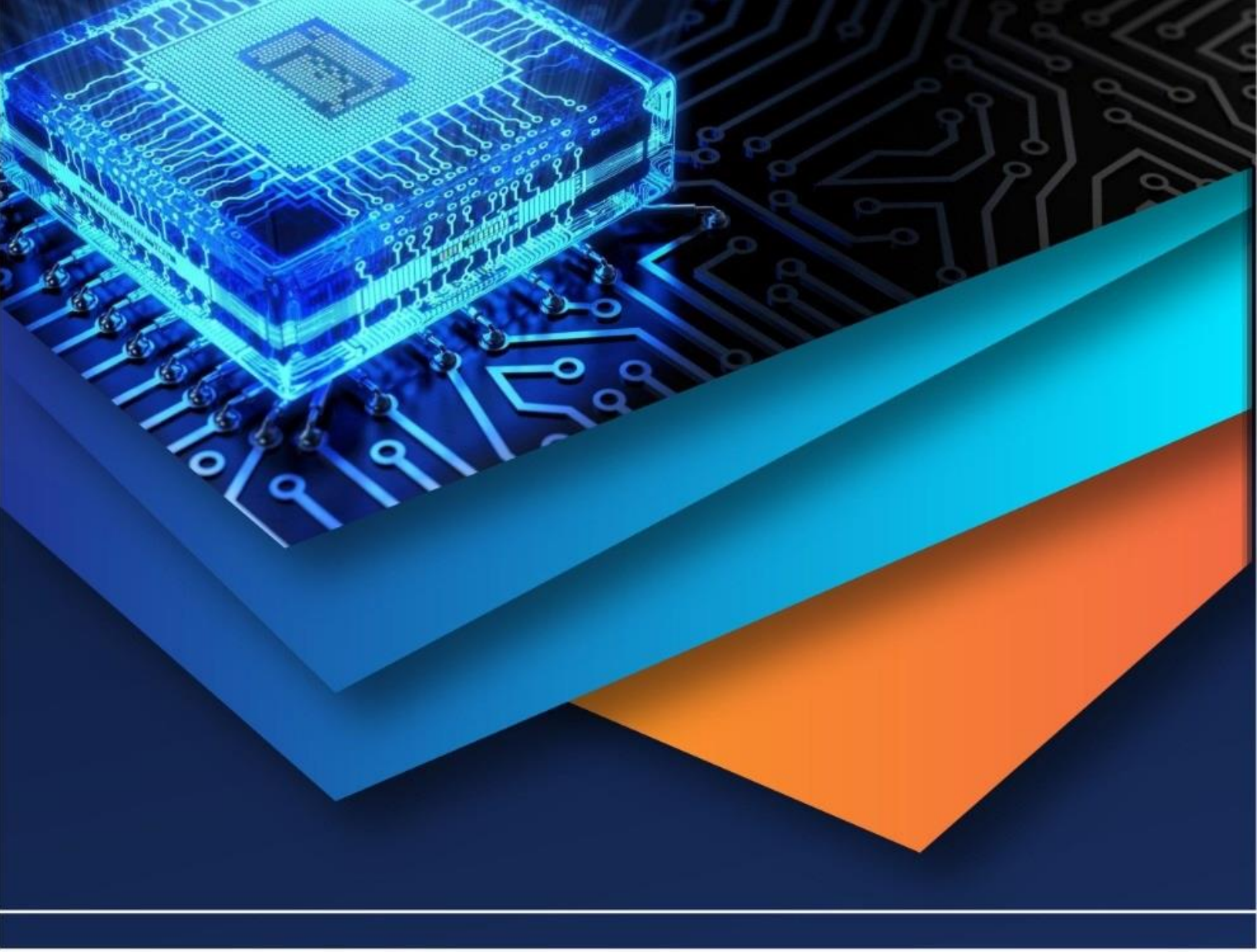

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