Augmented Reality Based Teaching In Classrooms

Faima Abbasi
Department of Computer Science
Bahria University
Islamabad, Pakistan
faimaabbasi1993@gmail.com

Ayesha Waseem
Department of Computer Science
Bahria University
Islamabad, Pakistan
aishawaseem95@gmail.com

Erum Ashraf
Department of Computer Science
Bahria University
Islamabad, Pakistan
erum.ashraf2011@gmail.com

***Abstract* — Augmented reality is a useful technique and has been of interest to researchers recently. Many real-life applications ranging from games to learning have been developed using augmented reality. The aim of this work is to improve student's understanding of realistic phenomenon of nature and enhance their capabilities towards learning. Augmented reality technique has proved itself in education as it replaces memory based learning to fun driven and conceptual schooling. In this paper, we have proposed an algorithm to support marker based augmented reality teaching methodology. A controlled experimental lecture in classroom was conducted with the usage of augmented reality technique. The delivered lecture was then compared with the traditional method of teaching. Post and pre-test were conducted to record the student's understanding which depicted that the proposed augmented reality teaching method is more proficient than the traditional one and plays significant role in improving student's grades.**

Key Terms— Augmented Reality (AR), Marker based augmented Reality (MAR) ,Conceptual Schooling, Augmented Reality Technique.

I. INTRODUCTION

Term "Augmented Reality" was first introduced by Tom Caudell at Boeing referring to head mounted digital display that directed workers in gathering bundles of cables for aircrafts [1][2]. Since then the usage augmented reality technique with different domains are growing at fast range and outcomes are becoming more and more dominating. The phenomenon of adding digital information onto real world framework is termed as augmented reality. The usage of this technology can enhance physical experiences of life with digital contents such as simulations using 3D models, audio, and video. R. Azuma et al. emphasized that the basic goal an AR system is to enhance user's perception by supplementing real world with 3D objects which exist in same physical space as real world [3][4].

The aim of this study is to improve the traditional teaching methodology with the usage of emerging technologies such as augmented reality and android platforms. The traditional ways of teaching involve direct communication between teacher and student in classroom using static paper based representation for students understanding. Especially chemistry students are unable to get the 3D picture of molecules which results in decrease of student's strength in chemistry subject. Hence a chemistry based lecture was arranged in order to demonstrate the chemical hybridization of methane molecule with the usage of AR technique. Experimental lecture was conducted because many of the students are unable to get the geometry of hybrid compounds.The current paper based representations don't relate to the actual 3D structures of compounds.

Methane is a natural gas mixture of hydrocarbons and is most studied compound in chemistry having general formula of CH_4. It contains two elements hydrogen and carbon which form methane through process of hybridization. Hybridization can be defined as the phenomenon of mixing of atomic orbitals of different energy levels and shapes to form new orbitals of similar energy level in order to gain stability. Atomic orbitals which participate in hybridization are s, p, d and f. The most common hybrid compounds are methane, phosphorous pentachloride and ethane.

Fig 1. represents the tetrahedral geometry of methane molecule. The evolution of methane undergoes three critical phases. These phases involve excitation of electron from 1s to $2p_z$ orbital, mixing of orbitals having different energy levels and formation of covalent bond between hydrogen and four sp^3 hybridized orbitals of carbon atom. The evolved compound is assumed to have same physical and chemical characteristics that of original one.

The rest of this paper is organized as follows. Related applications are discussed in Section II, Section III discusses the problem in general. The proposed methodology is discussed in Section IV and the evaluation results are presented in Section V. Section VI concludes this paper.

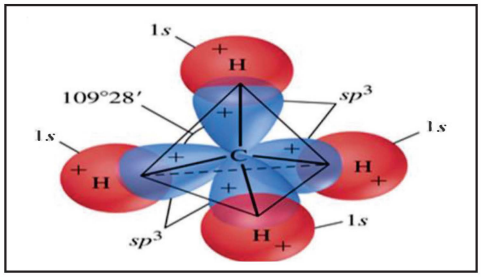

Fig 1. Tetrahedral Geometry of Methane

978-1-5090-4448-1/17/$31.00 ©2017 IEEE

II. Related Work

In literature, AR technique has been used in two different forms that are marker-based augmented reality and marker less augmented reality. Marker based AR requires some type of 2D image or QR code to produce the desired outcome when detected by the device such as camera or cell phone. While in case of marker less AR depends on the specification of device used such as GPS location. It can also be termed as location based AR. Anatomy 4D is the form of MAR application in which the image of the human body acts as marker. When marker is detected by the webcam it gets populated with organs, bones and nerves to get the detailed view of human anatomy. While starwalk is the form of marker less AR application in which user only aims the camera towards the sky to have the detailed view of stars, planets and orbiting objects within a certain range [5].Both of these forms are showing their dominance in many domains such as e-shopping, marketing and education but the focus of our study is marker based AR application.

In this digital era of dynamic technology companies need an innovative way of marketing in order to gain customer attention. Keeping in mind this critical demand of market Bule et al. [6] used AR to technique in order to grab customer's attention. They designed an AR system which detects the face of the customer through webcam using face detection algorithm. System calculates the detected face position and places the comical slogan above the customers head. The contents of the slogan are enriched with text and images. If no face is detected by the webcam it generates advertisement in the form of moving images. They tested this application in two fairs which gave amazing results. The application grabbed the attention of almost every visitor that passed by especially in groups.

Digital media these days is strongly influencing the shopping behavior of people hence for this purpose Khushal et al. [7] proposed MAR application for buying furniture. Their proposed study which mainly focuses on trying different furniture objects for home without visiting the shops. User places the marker at the position where he wants to place the object in room. Webcam is used to capture the live feed of the room and detects the marker. User selects the object from database in order to try the best fitted item in his room. In this way user can view the object in his room from different angles. Their proposed study addressed the issues of common people who generally find time consuming to visit the furniture stores.

Le et al. [8] used MAR in combination with hand gesture recognition to address some of the basic critical issues in geometry. The aim of their study was to manipulate 3D shapes and figures of geometry with hand gestures. Webcam detects the visible marker and with the usage of artoolkit virtual content is formed. Hand gestures then manipulate the position and motion of the virtual content to produce the desired results. Their study proved to be beneficial for the students having interest in geometry and helped them to acquire good grades.

Similarly, Antonia et al. [9] in his studies showed how augmented reality technique is used to improve learning activities of preschoolers. The main objective of their application was to show vertebrate animal classification which included the details of animal skins, their reproduction kinds and temperature. They presented an animal park over an AR marker having a group of animals showing their gestures from different angles. They applied this approach on two group of preschoolers that is control and experimental group. The results of the experimental group showed that MAR technique is effective in learning activities of students at their initial stages.

The relationship between molecules in chemistry is essential part to be understood by students in order to pass the course. For this purpose, Maier et al. [10] presented the concept of "Augmented Chemical Reactions". This concept implies the usage of MAR technique which uses a physical cube surfaced with black and white patterns as marker. The virtual contents were drawn at the top of the cube which forms an illusion showing chemical reaction. User can choose the molecule from the associated protein database. This study had a very positive effect on the students of chemistry.

Yilmaz et al. [11] presented the concept of "Educational Magic Toys (EMT)" which was developed using MAR technique. The aim of the study was to boost children imagination, skills and activities. They used flash cards, match cards and puzzles as marker to show virtual content. With the help of this MAR technique they taught the classification of fruits, animals, vegetables, vehicles and colors to children having age group 5-6. They conducted this experiment on the group of 33 children and 30 teachers. The experimental results showed that children showed great interest towards the flash cards as 3D virtual object appear on the card leaving a fascinating impact on them.

Similarly, Vate-U-Lan et al. [12] introduced the concept of "Augmented Reality 3D Pop –Up Book" in order to teach various aspects of English language through "Seed Shooting Game" setup. They used MAR approach for story telling in order to grab third standard student's attention by this fascinating technology. For the development of this application AR creator was made in use which itself makes use of cloud computing technology. The application has two modes that are screen mode and web camera mode or AR mode. Web camera mode presents this popup book in AR environment. This environment implies that firstly camera needs to detect the marker placed in front of it and secondly after detection the application will superimpose "Seed Shooting Game" setup over the marker which would be followed by predefined animation. For evaluation of this approach a group of 37 students (20 males and 17 females) at a local school had a post and pre-tests in order to know what impact AR left on their mind. The results showed that the female students learning capability were slightly higher than that of males. Hence the AR approach left positive impact on girls.

III. Problem Analysis

A. Abstract Nature of Chemistry

Many of the chemical processes and concepts cannot be seen or perceived directly with the bare eye. This is due to the abstract and complex nature of chemical compounds. Students at intermediate level cannot have clear concept or view of atoms, electrons, sigma bond, pi bond and delocalized electronic cloud. It becomes sometime arguable whether such entities exists or not in real world. Due to this reason students usually memorize all these concepts without any understanding in order to get good grades. Yarroch et al. in his studies found that in high school many of the students were able to balance chemical equations but at the same time unable to draw molecular diagrams to verify the proposed result of balance chemical equation [13][14]. Similarly Abraham et al. conducted their studies to identify the root causes of misconceptions of chemistry students. They concluded that only textbooks were not appropriate for understanding of chemical processes [15]. These studies, emphasize that a different approach based on existing one should be introduced in order to eradicate these drawbacks.

B. Strength of Students in Science Subjects

A scientific study involves a series of phases that are used to study a natural occurrence. These phases involve problem identification, problem analysis, and formulating hypothesis, performing experiment, making conclusions and then communicating results. Critical thinking is encouraged among students while participating in these processes in order to gain fruitful results. Due to the theoretical nature of science many of the students in world are abandoning science. According to famous acuity science subjects are hard to study. Fewer students are willing to pursue their professions in science subjects as it is mind numbing subject. A very clear result was obtained regarding student's strength from research conducted in an "Australian Journal". It highlighted that according to teachers, interest of students in science subject is decreasing at an alarming rate. In coming years, there would be significantly reduced enrolments in these subjects [16].

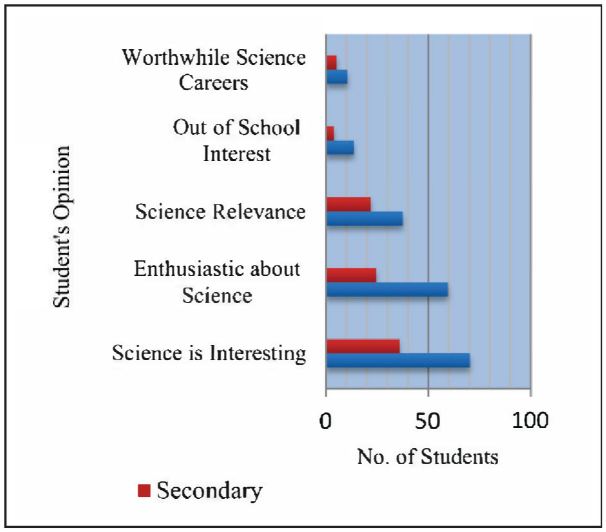

Fig 2. Drop Rate of Students

Dataset obtained from the Russell Tytler study in Re-imagining Science Education" shows the drop rate of students in science subject obtained at secondary and primary levels. The dataset was formulated on the basis of conducted survey. The survey was conducted to get the teachers opinion regarding the student's interest in science. Fig 2. shows graphical picture of students drop rate which was extracted from the dataset [16]. The results depicted that a new technological approach should be introduced for teaching purpose.

IV. Proposed Methodology

Merging of augmented reality approach with the chemical hybridization of methane enables the student to envision the abstract concept of hybridization at secondary level of schooling. It acts as a supportive tool for teaching methodologies.

A. Technical Environment

The application is developed for Android based hand held devices. The development of the application is supported by the usage of software. In order to design molecules such as carbon and hydrogen Autodesk Maya was made in use. Unity 3D platform was used for simulation of molecules with integration of vafuria SDK's to provide augmented reality atmosphere.

B. Conceptual Framework

Conceptual outline generally overlays the basis how application will execute in its favorable environment. For the effective performance of the application the target image is most important constraint to be followed. Molecular interaction is only possible if the target gets detected. In the proposed application the target is a simple 2D image which is detected by the application. The focus of our study is marker based augmented reality application. While application is executed on android platform it will make use of the camera resources and would be gathering target pattern by scanning the real world environment in the camera view.

The detection of target pattern or marker would form the basis of virtual content formation .Virtual content will pass its input to renderer to be displayed on screen.

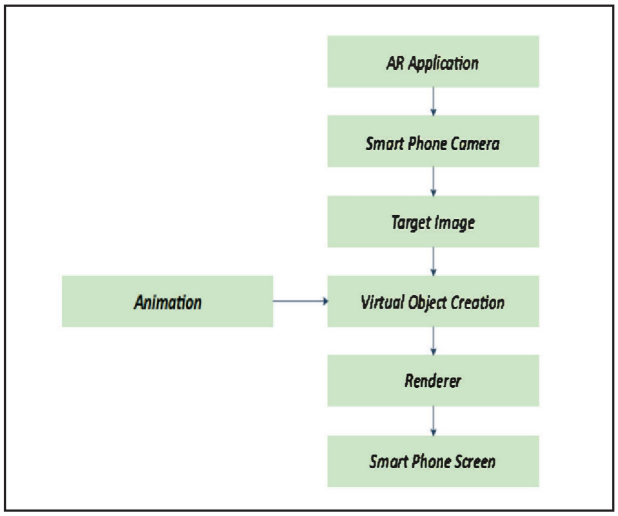

Fig 3. Conceptual Framework

C. *Experimental Setup*

The core functionality of the application depends on the availability of components or models. These components have direct reflectance with the stimulating molecules in the application. For designing components Autodesk Maya was considered appropriate platform as it offers variety of functionalities including texture, lights, fbx export camera and many more.

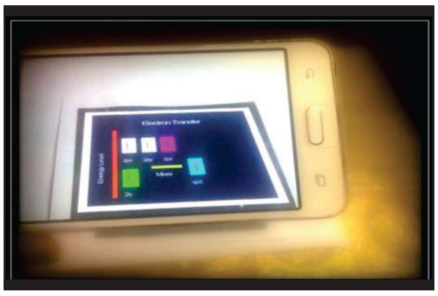

Fig 4. Excitation of Electron

All 3D objects were designed using basic polygonal shapes like 3D plane, cube and text for the purpose of electron excitation from one orbital to another to gain stability using unity platform as shown in Fig 4.

Carbon molecule was developed using basic polygonal mesh of sphere as it has close resemblance with carbon**.** Material and light properties were adjusted appropriately for the elegant look of the model. Hybridized carbon is formed after the excitation of electron to gain stability. Fig 5. shows semi hybridized state of carbon atom which is responsible for the evolution of hybridized carbon atom.

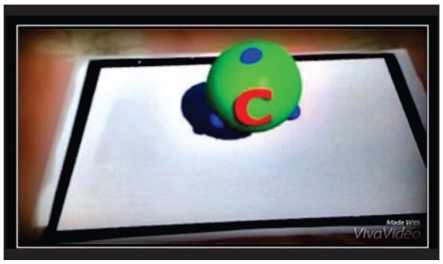

Fig 5. Semi Hybridized Carbon Atom

For the formation of Hydrogen molecule the sphere polygonal mesh was used as it resembles the orbital structure of hydrogen. The formation and designing of sp^3 hybridized orbitals is assisted by the polygonal mesh of cone and semi sphere with little amendments.

Emerging Orbitals involve the placement of material attribute of lambert with little transparency level and appropriate adjustment of lights and position. Transformation and grouping of 4 sp^3 hybrid orbitals gives rise to the tetrahedral geometry of carbon which is further joined by hydrogen as depicted in Fig 6.

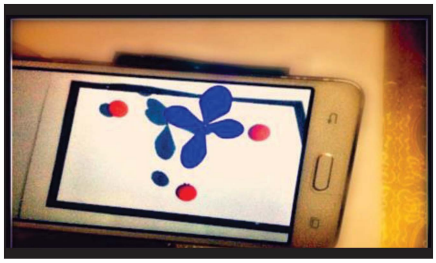

Fig 6. Covalent Bond formation

D. *Proposed Algorithm*

The study has been roughly divided into three major phases keeping in consideration the scope as stated above. The integration of these three phases stated in algorithm gives rise to real time augmented reality application. The application possesses the characteristics of 3 dimensions; interactivity, changeability, combination of real and virtual contents. Integration of these 3 dimensions gives rise to a synchronized AR application. Following is the proposed algorithm for the above described study.

1. *Target image detection through developed AR application (Marker Based AR application).*

2. *Virtual Object Generation on formerly detected marker which is done in following 3 phases.*
   - 2.1. *Excitation of electron is depicted by color change from one orbital to another with the usage of c sharp script.*
   - 2.2. *Transformation of carbon from non-hybrid state to the hybrid involves deactivation of existing state and activation of next state after every 2 seconds through scripting.*
   - 2.3. *Covalent bond is then formed by smooth transformation of hydrogen towards the hybrid carbon atom due to the scripting logic coded at the backend.*

3. *End Product Methane is formed and visualized through smart phone screen.*

V. Results And Disscussion

The MAR study is intended to enhance 3D visualization, giving more realistic representation of concept which increases the understanding of user in contrast with 2D static paper based representation. The molecular models used in the study have direct reflectance with the elements and are assumed to have same physical and chemical properties as of the original elements.

Bonding shared by the molecular models relate directly with that of covalent bonding shared by hydrogen and carbon. The transformation phase of carbon from non-hybrid state to hybrid state highlights the orbital mixing phase of evolution. All these assumptions assure efficient working and performance of application. Fig 7. Shows the augmented view of methane molecule which evolved from the above stated phase.

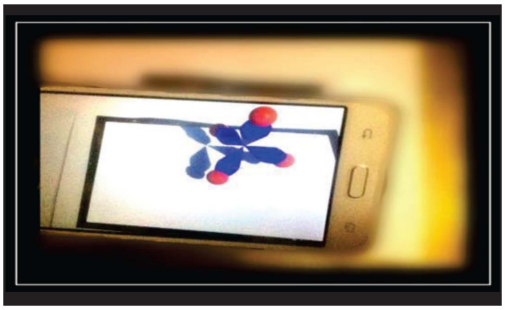

Fig 7. Augmented View of Methane Molecule

A. *Participants*

For the evaluation purpose a controlled experimental lecture was prepared to be delivered on the intermediate students at a local school in Pakistan. Overall 56 students took part in this activity and were evaluated according to the instructor's criteria of grading.

B. *Experimental Lecture*

The experimental lecture was prepared by instructor. In first 20 minutes introductory lecture was delivered to the participants regarding the phenomenon chemical bonding. Following this session pre-test of about 20 minutes was conducted in order to ensure student's equivalent prior knowledge regarding subject. The pre-test consisted of twenty multiple choice questions having perfect score of 20. Then these students were divided into control and experimental group on the basis of pre-test results. Same instructor was responsible for both the groups.

Then for experimental group students a detailed lecture was delivered to demonstrate the hybridization of methane using AR platform in 60 minutes. This lecture strongly emphasized how AR technique can be useful in formation methane. Further it gave them a clear 3D picture of methane and its hybridized orbitals. Following this, a training session was conducted for students to operate mobile devices in synchronization with the developed AR application. In the same 60 minutes for control group lecture was delivered to demonstrate the chemical hybridization of methane using traditional teaching methodology and tools.

In the end a post-test of 20 minutes was conducted in order to get the impact of MAR technology on students understanding and their learning activities. Post-test consisted of 20 multiple choice questions having a score of 20 regarding the both delivered lectures. Lecture delivered using AR technique showed the positive results of the student's understanding as it provided a 3D view of the molecules during the course of chemical hybridization.

C. *Analysis*

Before delivering the experimental lecture, a pre-test was conducted in order to ensure the equal capabilities of students regarding the subject. The results of the pre-test gave us a mean value of 11.2, standard deviation of 0.99 and coefficient of variation 0.42. These values indicate that there is wide variance among the data points as mean value is far away from standard deviation. After the participation of groups in the learning activity, they took a post-test whose results are recorded in table below.

TABLE I. **RESULTS OF POST –TEST**

Group	Variables		
	Mean	*Std. Deviation*	*Coefficient of Variation*
Control	9.5	3.42	0.36
Experimental	12.6	3.12	0.31

Fig 8. below shows the comparison of post test results of both the groups. Comparing the results of both groups we can summarize that the students can learn actively in technological environment.

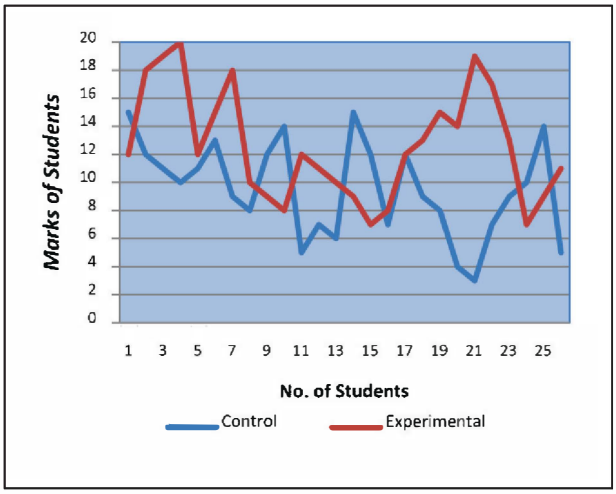

Fig 8. Comparing Results of Post-Test

The factor mean indicates the central location of the dataset. The above table depicts that control group mean is less than that of the experimental group which shows that AR technique is beneficial for learning purpose.

As we can infer from above table that value of standard deviation of control group is greater than that of experimental one hence the uniformity of data is greater in experimental group. We can also say that the data points are closer to the mean in experimental group indicating fairly identical responses.

The value of coefficient of variation of experimental group is closer to zero thus we can infer that the responses of candidates are similar. Hence we can say that students can easily adopt AR platform. The three factors show that the students of control group gave variable responses. While if we talk experimental group, results showed uniformity in responses which indicates that the AR platform increases the student understanding regarding abstract nature of concepts.

The above results were also illustrated in the form of grades by the instructor which also gave us a clear picture of the significance of AR platform. The table demonstrates that there was a significant difference in the grades of control and experimental group.

TABLE II. GRADE ANALYSIS

Group	Variables		
	A	*B+*	*B*
Control	7.7%	42.3%	50%
Experimental	30.7%	42.3%	27%

Fig 9. Below shows the graphical representation of grades of the post test conducted. In control group only 7.7 percent students were able to acquire "A" grades while in the case of experimental group the value was increased to 30.7 percent. Similarly in control group 50 percent of students acquired "B" grade while in experimental group this value was decreased to 27 percent.

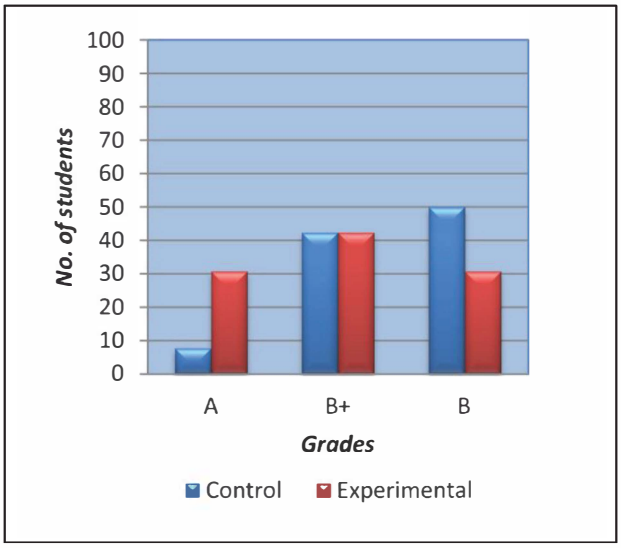

Fig 9. Outcomes of Post-Test in Form of Grades

The obtained results from the tests were used to find the students perception of merging augmented reality with chemistry and its usage as teaching tool. Majority of students being interviewed indicated that they are delighted working with this technology as it would be responsible for making lectures more exciting and fun driven ultimately passing the enrolled course.

VI. CONCLUSION & FUTURE WORK

The proposed technique is the novel approach which can increase student's understanding of chemical processes. The proposed application demonstrates phenomenon of chemical hybridization through three critical phases in augmented reality environment. In order to evaluate the application, controlled experimental lecture was conducted along with pre and post-test. The results showed that the proposed approach can be adopted for teaching purpose. Our approach provides a new methodology for students to learn chemistry easily and efficiently.

Research work can be enhanced further to incorporate many interesting features. Addition of the virtual buttons can enhance the usability characteristics of the application. The scope of study can also be increased by addition of other hybridized compounds in the application such as phosphorous pentachloride and ethane. Apart from this more generic platforms can be used to raise the standard and functionality of the application in relation with developed one.

ACKNOWLEDGMENT

We thank Dr M Muzammal for his encouragement and help in this work.

REFERENCES

[1] K. Lee, "Augmented Reality in Education and Training", TechTrends, vol. 56, no. 2, pp. 13-21, 2012

[2] Mekni, Mehdi, and Andre Lemieux. "Augmented reality: Applications, challenges and future trends", Applied Computational Science—Proceedings of the 13th International Conference on Applied Computer and Applied Computational Science (ACACOS '14) Kuala Lumpur, Malaysia. 2014.

[3] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre, "Recent Advances in Augmented Reality", IEEE Computer Graphics and Application, vol. 21, no. 6, pp. 34-47, Nov.2001.

[4] Pandya, Aniket. "Augmented Reality", International Journal Of Research In Advance Engineering 1.1 (2015): 10-19.

[5] Green, Marybeth, Joy Hill Lea, and Cheryl Lisa McNair. "Reality check: Augmented reality for school libraries", Teacher Librarian 41.5 (2014): 28.

[6] J. Bule and P. Peer, "Interactive augmented reality marketing system", In: World Usability Day, Paper ID 2505, 2013.

[7] Khairnar, K., Khairnar, K., Mane, S., & Chaudhari, R. "Furniture Layout Application Based on Marker Detection and Using Augmented Reality", International Research Journal of Engineering and Technology, 2(7), 540-544, 2015.

[8] Le, Hong-Quan, and Jee-In Kim. "An Augmented Reality Application with Hand Gestures to Support Studying Geometry." Korean Journal of Augmented Reality, 160-161, 2016.

[9] Cascales, Antonia, Isabel Laguna, David Perez-Lopez, Pascual Perona, and Manuel Contero. "An experience on natural sciences augmented reality contents for preschoolers", International Conference on Virtual, Augmented and Mixed Reality, pp. 103-112. Springer Berlin Heidelberg, 2013.

[10] Maier, Patrick, and Gudrun Klinker. "Augmented chemical reactions: An augmented reality tool to support chemistry teaching", 2013 2nd Experiment@ International Conference (exp. at'13). IEEE, 2013.

[11] Yilmaz, Rabia M. "Educational magic toys developed with augmented reality technology for early childhood education", Computers in Human Behavior 54 (2016): 240-248.

[12] Vate-U-Lan, Poonsri. "An augmented reality 3d pop-up book: the development of a multimedia project for English language teaching", 2012 IEEE International Conference on Multimedia and Expo. IEEE, 2012.

[13] Yarroch, William L. "Student understanding of chemical equation balancing", Journal of Research in Science Teaching 22.5 (1985): 449-459.

[14] Krajcik, J. "Developing students' understanding of chemical concepts", In S. Glynn, R. Yeany, & B. Britton (Eds.), The psychology of learning science (pp. 117–148). Hillsdale, NJ: Erlbaum, 1991.

[15] Abraham, Michael R., Eileen Bross Grzybowski, John W. Renner, and Edmund A. Marek. "Understandings and misunderstandings of eighth graders of five chemistry concepts found in textbooks", Journal of Research in Science Teaching 29, no. 2 (1992): 105-120.

[16] Tytler, R. "Re-imagining science education: Engaging students in science for Australia's future", Australian Education Review 51. Melbourne: Australian Council for Educational Research, 2007.