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Research Article

DISTRIBUTED COMPUTER SYSTEM TO DISPLAY THE ATOMIC ELEMENTS IN AN OBJECT WITH AUGMENTED REALITY

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Abstract

The present research work aims to propose a didactic strategy to improve the teaching-learning process in the field of Chemistry. In that sense, this research is implemented at the Agustín de Hipona School in Coatzintla, Veracruz, Mexico. For experimental purposes, the platform is only implemented with teachers of subjects related to chemistry at middle school and high school levels. To understand the importance of the elements of the periodic table, different didactic strategies are used, for example: summaries, exhibitions, educational videos and laboratory practices. However, these focus on general knowledge and rarely focus on analyzing what are the chemical elements that are present in our environment. Thus, in this project a platform is designed in which students can visualize the chemical elements that are present in the objects around them such as the table, pencils, food, etc. The platform works as a scanner that shows the elements of said objects just by focusing on them. The platform is automated as a mobile application and uses cutting-edge technology such as augmented reality.

Keywords: Computer System, Augmented Reality, Chemistry.

INTRODUCTION

Chemistry should become in the astronomy of the atomic world… Alfred Warner. Science is a tool which enable us knowing our environment and developing solutions to live in harmony with all the inhabitants. There are many ways to classify Science, according to the study object, it classifies in two categories: formal and factual (Sampieri, 2018). On the one hand, formal Sciences studies analytics statements, which deduces in postulates and theorems. On the other hand, factual Sciences interpret ideas into facts and experiences, therefore it requires observation and experimentation. This kind of Science classify in social and natural. About the latter, Chemistry is included, where this research focuses. That Science study the composition and properties of matter and the transformation that it experiments without change the elements that comprise it (Chang, 2016). Due to the quite importance of the discovers related to Chemistry, the United Nations General Assembly proclaimed the International year of the Periodic Table in 2019. The principal aim of this initiative was recognized the critical function of Chemistry in the development of solutions to improve the life quality (Química y Sociedad, 2019). Science learning could catalogue as an important challenge in the develop of country's educational system. In all the world is registered a poor educative level in Science according to the last test of Organization for Economic Co-Operation and Development (OECD, 2019). In national tests, the performance in Mathematics was analyzed, which is the base in the Chemistry field. According to the last PLANEA test, only 66.2% of high school students demonstrate problems to resolve Math operations and 2.5% is proficient in the area (SEP, 2017). Although these results, México counts with many skillful students in Chemistry. For instance, Mexican students won medals in International Academic Contests (Redacción AND 40, 2019). In that sense, it is important to still working to reduce the knowing gap in the country.

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About our study population, this research is implemented at Colegio Agustín de Hipona in middle school and high school. The college localizes in the town of Coatzintla, Veracruz, México. Attends the students demand of Coatzintla, Poza Rica, Papantla and Tihuatlán city. The middle school and high school systems are general. Both levels share teacher's workforce who teach around 74 students at the former and 44 at the latter (Cuenca Lerma y Liahut Flores, 2020).

LITERATURE REVIEW

Education is continue changing and Information Technologies leverage this situation. Some cutting-edge technologies are applied to improve the learning-teaching process and nowadays the use of Augmented Reality is a trend (Díaz-Campos, 2016). Augmented Reality consists in combine physical spaces with virtual environments. It expands the information spectrum and it could be applied in whatever knowing field. This kind of technologies provide a revamp in methods to explain a topic and boost the students interest in learning (Martínez García y Dalgo Flores, 2018). There are many projects which implements this technology. For instance, Aguirre Brito (2016) develop a research where uses AR to improve the user experience in tourism activities. Tourists uses their smartphones to discover the most important information of the city that the visited with only focuses a special target. Moreover, Fracchia *et al.* (2015) use Augmented Reality as a resource to improve the experience in reading books about Science at Elementary School. That activities proposes different forms of interact with a computer. Another research is implemented in the biology field. A robotic simulation of a plant is developed to teach all the biological process (Chang, 2014). Also, a robotic device based in Arduino is proposes to move the plant through a room and interact with the environment. All the results are visualized with an AR application. In Chemistry courses Cheng and Chu (2016) uses an AR tool to display microscopic parts of a molecule. Hou and Lin (2017) create a mobile game where students visualize

the reactions in laboratory practices and Jin *et al.* (2019) developed an Augmented Reality solution to read better Chemistry books.

METHODOLOGY

General Objective

Design a strategy to facilitate the information access about the elements of periodic table which are in the daily life of users.

Specific Objectives

- Design a repository which contains information about elements of the periodic table that are in a scholar context.
- Implement the strategy which facilitate the access to information about the elements that are in our daily life through a mobile device.

Platform Design

The purposes of this paper are facilitated the access to information about the elements of periodic table which are in the objects of our daily life with only focuses. In that sense, it could be possibly known that date without use online search engines like Google, Bing, etc. The uses of search engines require invest a great deal of time to choose trustworthy sources of information. Instead, the user only needs to take the object and scan on the platform to know the elements thar comprise it. To automatize the platform, Information Technologies are implemented. Therefore, it is proposed the mobile application *Atomic Reality* (see figure 1) to achieve this goal.

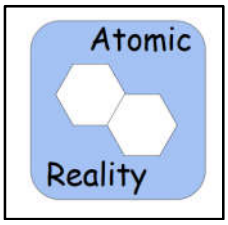

Figure 1. Application icon

Software architecture

The artifacts of the platforms are implemented with a client – server architecture (Coulouris, 2017; Xu, 2015). The mobile applications are considered as clients and computers which contains Augmented Reality information as servers (See figure 2).

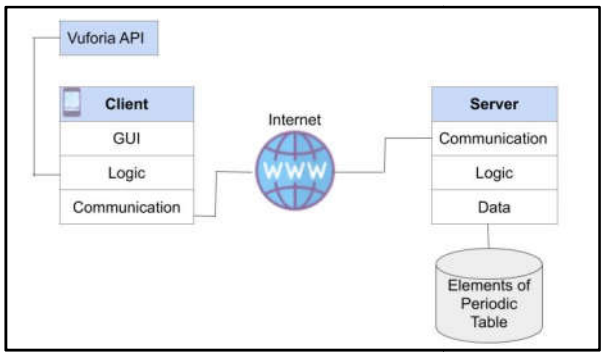

Figure 2. Software Architecture

Client is structured in a three-tier model. The first tier is the Graphic Interface User (GUI) which uses to interact directly with users. The logic tier processes the solicitudes of users and calls communication tier to retrieve information from server. Also, logic tier uses a Vuforia API to recognize objects with the device camera. Server is structured in a three-tier model too. The first tier is the communication which receives solicitudes from the client artifact. Each solicitude is processing with the logic tier and in case that needs information of the database, it calls communication tier to achieve the task. Both artifacts communicate through internet. The protocols run using HTML with a REST API that encapsulates data with JSON and encode it using the SHA-256 standard (Agocs and Goff, 2018).

Software Implementation

The requirements explained at software architecture are implemented with the technologies of Table 1.

Table 1. Technology to automatize the platform

	Client	Server
Back - End	C#	PHP
Front - End	Unity Editor	-
Data encapsulation	JSON	
IDE	Unity	Brackets
REST API	Retrofit	PHP Slim
Data Store	Sqlite	MySql
Publication Platform	Google Play	Hostinger

About virtual objects, the first version of the software uses 2D images to show the elements of periodic table which are presented in a product.Such images are created in a specialized software. Once created, are imported to Unity IDE to use in an Augmented Reality environment. A tridimensional plane is used to contain the image in the virtual world.

Software use cases

To understand better the functionality of the system (See figure 3). It is proposed a fictional scenario where Gemma, a high school student, realize that Atomic Reality is available in their region. Therefore, she decides install that to improve her Chemistry knowledge

Figure 3. Recognizing objects' elements

Discover elements of periodic table which comprise an object

Gemma ends her sport class, then she goes to get lunch and buy a bottle of water because she is thirsty. After that she realize that the bottle has a target which could be read by the mobile application. In consequence runs Atomic Reality in her smartphone and focuses the bottle. When the application recognizes the target, automatically display two elements of Hydrogen and one of Oxygen that comprise water.

Promotion of a brand: The student is amazed by the technologies used to discover how the periodic table is present in everything around it. The next day she goes to the supermarket to buy groceries and decides to buy some bottles of water in order to share with her family what she discovered during the break the day before. When acquiring them, one of the managers of the store informs her that other products of the same brand are compatible with the mobile application, consequently she decides to purchase these products in order to know the elements of the periodic table that make them up.

Sharing content on social networks: Because the mobile app uses augmented reality technology, the elements of the periodic table are displayed on top of what the phone's camera is projecting. That is why Gemma takes a screenshot and shares the image on his social networks Facebook, WhatsApp and Instagram to invite his friends to use this technology.

Experimentation

The research results were presented to the teachers of subjects related to chemistry in middle school and high school. These subjects are shown in Table 2.

Table 2. Subjects related to Chemistry at Colegio Agustín de Hipona

Middle School	High School
● Science and Technology. Biology. ● Curricular Anatomy (Medicinal Plants). ● Science and Technology. Physics. ● Science and Technology. Chemistry	● Chemistry I. ● Chemistry II. ● Physics I. ● Biology I. ● Physics II. ● Biology II. ● Ecology and Environment. ● Selected Topics from Biology I. ● Selected Topics from Physics I. ● Selected Topics from Chemistry I. ● Selected Topics in Biology II. ● Selected Topics from Physics II. ● Selected Topics from Chemistry II.

Teachers were given a survey that presents claims and was measured using the Likert scale (see experimentation specifications in Table 3). In order to verify the ease of access to information, the following variables shall be measured:

- Information retrieval time: Refers to the amount of time the user spends getting information from items in the periodic table that are present in an object in their environment.
- Use of already known technologies: refers to the skills that the user has in order to use the technologies with which the proposal is implemented.
- Experience of use: refers to the intuition of the mobile application, so that the user appropriately recognizes the distribution of the functions shown in the interface.
- Understanding the information displayed: refers to the user comprising the content displayed in the interface, in this way it is verified that the elements of the periodic table that are present in an object are clearly displayed.

Table 4 shows the statements by which each variable is measured.

Table 3. Experimentation Specifications

Factor	Description
Subject	Teachers of the Colegio Agustín de Hipona at the high school and high school level who teach a subject related to Chemistry. Within the teaching staff only 8 teachers meet this feature.
Hiring	They were invited to participate through a statement issued by the school's principal at both high school and high school levels.
Methods	Each teacher was sought out at times they deemed relevant to experimentation. First they were explained the characteristics of the project, immediately the functional prototype was shown and finally the survey was applied along with the informed human consent format.
Risks	Physically, no risks were found because the experimentation took place on the school premises and during business hours. Psychologically, there are no risks either because the mobile app displays content suitable for all ages.
Benefits	Expanding the landscape of technological applications through.
Privacy Protection	Each participant's personal data will not be published. They were only used to fill out the formats of the contest, however, in the poster and possible publications derived from the research will only show the answers and the number of participants, no mention will be made of the name of the teachers.
Informed human consent process	Each participant was shown the reported human consent format. In this format the above concepts are explained, after which the participant can decide if he wants to participate in the research.

Table 4. Measuring Variables

Variable	Statement	Answer
Information recovery time	A1: The Atomic Reality platform reduces the time to access information about periodic table items that are present in an object compared to using internet search engines.	*Totally agreed *Agree *Neither agree nor disagree *Disagree *Totally disagree
Understanding the information displayed	A2: The platform must use augmented reality to display the periodic table items that are present in an object. A3: The information displayed on the platform is useful for improving the teaching process - learning the periodic table. A4: I would use the Atomic Reality platform as a teaching resource in the subjects that I teach.	
Experience of use	A5: The graphical interface of Atomic Reality is intuitive	
Use of well-known technologies	A6: The platform should be implemented as a mobile app on Android.	

Regarding the results of the experimentation. When applying the survey, we realized that 75% of the population totally agrees that the platform reduces the time of access to information on the elements of the periodic table that are present in an object compared to the use of engines search on the internet. The remaining 25%agree. Regarding the use of augmented reality to show the elements of the periodic table, 62.5% totally agree, 25% agree and 12.5% neither agree nor disagree. In addition, 75% of the population totally agrees that the platform is useful to improve the teaching-learning process of the periodic table. The rest of the population is divided between the category of in agreement and totally in disagreement in this area. 87.5% of the population agrees at least to use the platform as a didactic resource in the subjects they teach. The remaining 12.5% neither agree nor disagree. Likewise, 100% of the population agrees at least that the graphical interface is intuitive and finally 62.5% fully agree that the platform should be implemented on Android, the other 25% agree and the remaining 12.5% neither agree nor disagree. These results are summarized in Figure 4. By grouping the results of the research by variables, it was obtained that 100% of the population agrees at least that the platform reduces the access time to information about the elements of the periodic table that are present in an object. 66.67% totally agree that the information shown in the system is understandable, in this same variable 20.83% agree, 8.33% neither agree nor disagree and only 4.17% totally disagree. In addition, 100% of the population agrees at least that they like the experience of using the system and finally at least 87.5% fully agree that technologies already known to users are used, the remaining 12.5% do not. you neither agree nor disagree. These results are summarized in Figure 5.

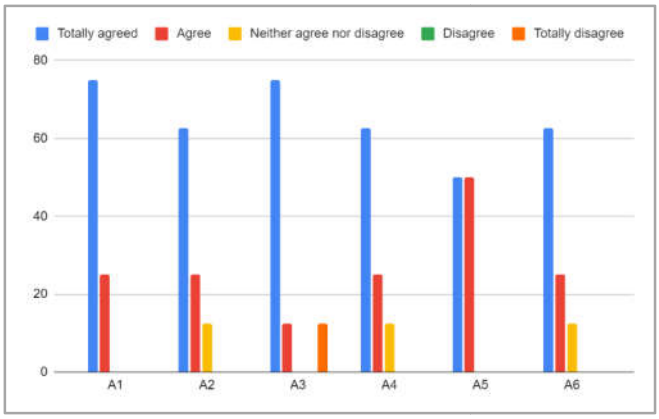

Figure 4. Results per affirmation

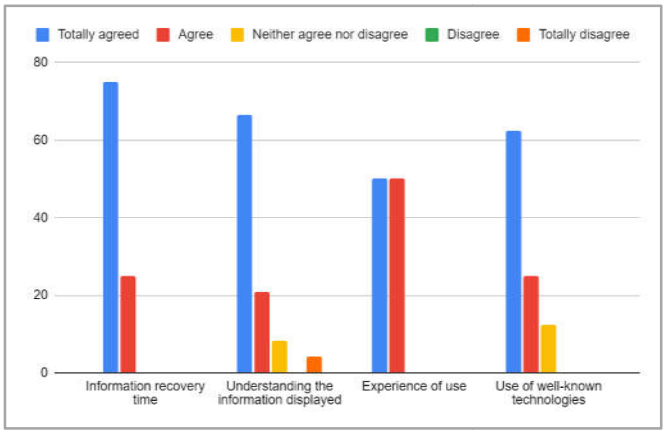

Figure 5. Results per variable

DISCUSSION AND CONCLUSION

Due to the fact that in all the variables measured through the survey it was obtained that at least 87.5% of the teachers who teach a subject related to chemistry at the school agree at least that the platform reduces the time retrieval of information about the elements of the periodic table that are present in an object, shows comprehensible information, has a feasible user experience and is implemented using technologies already known to the user. It is concluded that the hypothesis is true, in such a way that the use of the Atomic Reality platform facilitates access to information about the elements of the periodic table that are presented in daily life objects within the educational level of secondary and high school at the Agustín de Hipona School in Coatzintla, Veracruz. Thus, both teachers from Colegio Agustín de Hipona and teachers from other institutions in the same subjects will be able to use Atomic Reality to encourage their students to value Chemistry as an important branch of knowledge in their context. In addition, work is being done to fulfill some of the objects of the UN's sustainable development agenda. Likewise, the platform is congruent with the work objectives set out in the framework of the international year of the periodic table. In the same way, it is contributing to the promotion of scientific and technological vocations in Mexican youth. As well as the incursion of women in areas such as Science, Technology, Engineering and Mathematics. Regarding the technical part, with the development of this research work we have the development of a mobile application that operates on the Android operating system. This application meets the Google Play publication criteria, which is why it is ready to enter the market. As future work, it is proposed to work on a collective knowledge platform, in such a way that the population trained in the area of chemistry can upload the chemical elements that are present in the elements that they know, in this way it will increase more quickly the system database. In the same way, it is proposed to include the simulation option, in such a way that the user can appreciate the changes that the objects will undergo when combining them with others or when subjecting them to certain chemical and physical conditions.

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