Augmented Reality in education

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***Abstract*:** The paper presents Augmented Reality (AR) as a step between reality and virtual reality for the benifit of education. After some introductory example of where AR heads, the technology itself is explained. Then, we describe the modules of the AR portal that we have developed and how it can be used. We give examples of its use in university courses and activities. Furthermore we describe an experiment that we set up at a secondary school to help in popularizing chemistry and raising grades of students, besides making then enjoy involvement with the topic. Our results are very positive, so we consider our efforts to be a starting point for further developments.

***Key words and phrases*:** augmented reality, AR book, education, chemistry, AR marker

1.   Introduction

Our world has been developing rapidly for the last hundred years and this process was even increased by the spreading of Personal Computers. The domination of Information Technology influences everyone's life. "A school of today has to coach their students for a society that not yet exists. That is how the surrounding world becomes more and more complex." [1] No wonder, keeping education up to date is vital. For the last ten years, educational institutes managed to adopt modern devices or as they are commonly called: Informational and Communicaltional Technologies (ICT) and their presence still have to be increased. Professional experiments aim at proving ICTs' efficiency, though there are sceptics. Those who doubt these techniques' necessity are reasoning with the evidence of past: education used to succeed without the usage of modern equipment, the good old stuff - books, board, choke - has to be enough to teach anybody for life. On the contrary, the latest generation (generation-Z born in the prosperity of Internet) has to face a completely different reality when finishing social studies as the ones before. [2] It is highly recommended to make use of ICTs benefits like AR in order to raise and maintain their attention throughout a class.

2.   AR on the move

The emergence of AR (Augmented Reality) can be estimated around 1968 when Ivan Sutherland created the first head-mounted 3D display which projected a simple framed graphical view into a room. Later, in 1992, Tom Caudell who worked for Boeing as an engireer created a method that could virtually show cables and other parts of the aircraft and its location without having to open the shield of the machine. Later AR applications were developed for airmen that contained full interactive transparent screen providing the basic flight information. The next version of this solution was a helmet mounted display. [3]

In everyday life AR appeared first at live sporting broadcasts on television: prompt and actual information could be visualized, like the flag of the winner's nation in the moment of victory.

AR is a new 3D technology that merges phisical and digital world in real time. In practice, a 3D model or animation is assigned to an AR-marker (a printed black-and-white picture) that is detected by a webcam, then the model appears on the screen. If you are moving the marker, the displayed model or animation (or sound…) is transformed on the flow. Sights of the real world, with virtual objects superimposed upon or composited with the real world are displayed together.

One of these options offering similar solutions is a free software, ManyCam (www.manycam.com), with which you can use many masks, glasses's, hairstyles, moreover you can change the background for a moving picture. With the help of advanced technology such as object-recognition and computer vision, the information surrounding the user may become inter-active and digitally available.

Controling computers are possible without a mouse or a keyboard. These methods are helpful for disabled people who can manipulate cursor with their own glance. CamSpace is one of these possibilities (www.camspace.com), creating a control device from any object that allows to use gestures or everyday products as a mouse.

Due to the remarkable evolution of mobil technology, extended moblie development is expected next to computer revolution. In the future, the monitor is about to be replaced by AR glasses, furthermore contact lenses. AR-technology is spreading in industry, commercial marketing and entertaining, probably a few years later, it will be invade education too.

3.   AR technology

It can be distinguished the type of extended reality from editing to positioning the place of virtual element.

The first position and direction based AR was used on cell phones. The purpose was the real picture and information increasing on cell phone screen. The plus information was beared by POI (Point Of Interest), what is an expression for a place using by different programs. The POI defines the place of points and these points can be important for somebody [4]. This points could be general informations (street, house number, phone number), but geographical coordinates as well. The information needed to extend real picture is obtained by compass, GPS position and speed-up sensor.

The GPS (Global Position System) allocate where exactly is the mobile instrument and with help of this it can be exactly calculated how far is the POI from the actual position. The compass show in what direction the cell phone is oriented and from this we can find out if one POI is in a picture observed by cell phone camera on a parallel level with Earth. The speed-up sensor can show the cell phone inclination angle comparing with parallel level and from this calculating another POI position. Today we can found a few adapations like this, t.ex Wikitude (www.wikitude.org), Layar (www.layar.org) and Junaio (www.junaio.org)

figure 1. Wikitude in use

Another type of extended reality is the marker based AR. In this case we are looking for a special part of the picture, what is different and can be easily recognised and distinguished by from enviroment. Is worth using an error recognising code, because with this the AR marker won't recognise the small faults. Based on this, the marker is a black square in white ground, with a determined width border; on this border is an unique part of black-white picture.

For marker recognisation in first step we need to detect the borders. The next is the contours defining, the contours can ductiled in polygons and these polygons must be filtered on squares. After we got the squares, we need samples from indoor and outdoor points near contours because from these we can filtrate possible markers. Outside from contours, to a specified distance it must be bright points and inside from contours (to a specified distance) it has to be dark points. In this case with a big probability we can find only real markers in possible elements. [5] This task can be solved easily with OpenCV picture editorial library (opencv.willowgarage.com/wiki/). After successful detection, the marker can be replaced by virtual element and this can calculate from marker-movements the necessary transformations and mediate on screen the virtual reality with the real picture.
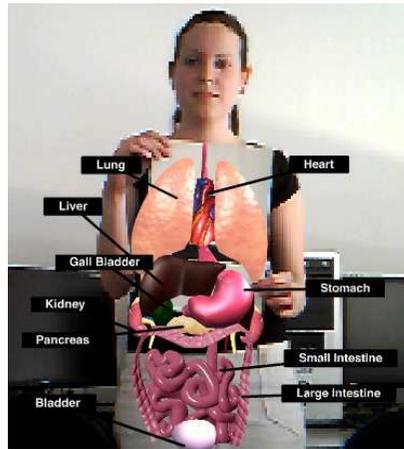
figure 2. AR-marker

figure 3. AR in use

http://www.learnar.org/

AR technology does not require an AR-marker, but can be substituted by fine-tuned pattern recognition modules. The mask example in the previous chapter can use facial recognition software. In this case you don't need a physical AR-marker since the software recognizes the face of person and puts the mask on the face. Mask will be stuck on the head while moving.

The FD – Face Detection is a computer based technology to optimize human face and positioning in digital pictures. FD detect the human face lineament and don't take in consideration the enviroment (trees, people, bodies and other secondary objects). [6].

figure 4: Face recognize

4.   AR portál

On ELTE IK Software Tecnology Laboratory and Virtual Reality project we founded a portal to review and present AR technonology (http://arportal.elte.hu/). The goal is mapping and compar-

ing the existing and most evoluate AR today. This prota can be not only be an informational base, but a possibility to prove nor only for interested student, but for developers as well. We implemented in portal different components, in following subsections you can read about these. [7]
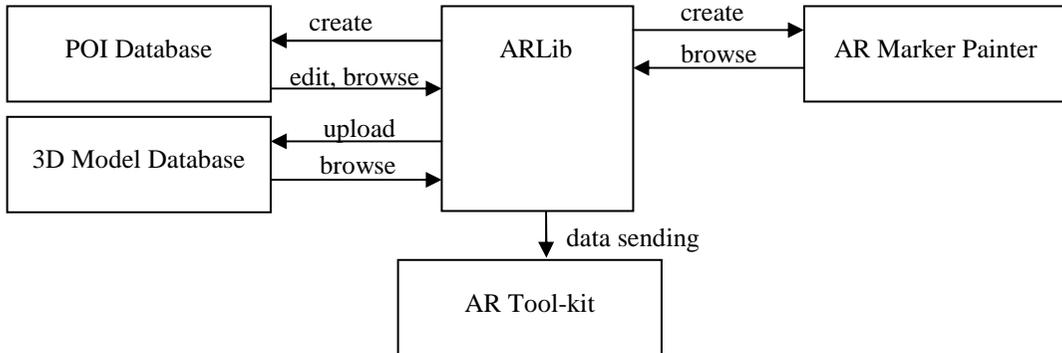

figure 5. System of AR-portal

4.1. POI component

First we made the surface and POI database necessary for the position and direction based AR technology. It is possible the visualise interesting points in portal with help of components; we can portray important places, interesting points. Using is very simple, with POI editor we need to create a file with points of interest, strictly to comply with all colour-tactical rules, including tags and other optional terms.

POI files type are t.ex GPX, CSV. After this, if everything is proper with colour-tactical rules, on the map show up marked places. The component has not only the POI file with points, but 3 other functions as well. It is possible editing, searching and exporting files. The database store the necessary POI files. This component make possible – most on cell phones used – creating and testing POI databases.

4.2. AR marker component

The next component is AR Marker Painter, what is a normalised Java applet. With help of this it can be planned, designed and drawned different markers and these markers can be saved on used computer and in portal database. For marker paiting we use 5 different drawning tools, many figures, greek letters and ready made backgrounds. Because of certified Java Applet the user can save on his computer the Java based ready picture.

4.3. ARLib component

With mentioned components we can create different entitates or handle the ready ones. Creating a new one, the program automaticaly generate a new file, - and for saving in main database – the different entitets can be stored in a common panel. Handling all these we need a uniform management table. The ARLib component handling this uniform table.

4.4. ARToolkit komponens és használata

Most important component is the FLARToolKit program. This is a Flash based open source code library and with this we can develop extended virtual applications. This program is based on NyARToolkit (http://nyatlajp/nyartoolkit/wiki/index.php), what is the ARToolKit (www.hitl.washington.edu/artoolkit/) version based on Java. The FLARToolKit recognise from the sysin picture the marker and calculate his position in 3D world, using computer „viewed" algorithms for this. After calculations the program positioning the model, video or picture.

For 3D grafical elements he's using different 3D Flash Engines (Papervision3D, Away 3D, Sandy, Alternativa 3D). In this component we can choose ready and on portal uploaded markers and one of ready 3D modells. After this happened, the portal navigate us on a page where we can reach our personal developed, FLARToolKit based ActionScript application. Then in first step schoosed and printed marker kept in the front of web camera we can see on monitor the choosen model and we can use preferable modell for choosen marker. We can use a personal marker (with dae.extension).

The 2 main methodes of program are:

```
private function init3D(e:Event) :void {
      scene = new Scene3D();
      camera = new FLARCamera3D(FlarParams);
      camera.z = -30;
      view = new Viewport3D(640, 480, true);
      lre = new LazyRenderEngine(scene, camera, view);
      var request:URLRequest = new RLRequest("params.txt");
      request.method = URLRequestMethod.POST;
      var loader:URLLoader = new URLLoader();
      loader.dataFormat = URLLoaderDataFormat.VARIABLES;
      loader.addEventListener(Event.COMPLETE, completeHandler);
      loader.load(request);
      model = new DisplayObject3D;
        function completeHandler(evt:Event) :void {
          var modelMatList:MaterialsList = new MaterialsList;
          var modelMat:BitmapFileMaterial=new BitmapFileMate-
rial(loader.data.text)
          modelMat.doubleSided=true;
          modelMatList.addMaterial(modelMat,loader.data.mat);
          modelframe.load(loader.data.mod, modelMatList);
          model.addChild(modelframe);
          scene.addChild(model);
      }
      addChild(view);
```

```
        addEventListener(Event.ENTER_FRAME, loop);
        }
private function loop(e:Event) :void {
        if (marker != null) {
        model.transform = PVGeomU-
tils.convertMatrixToPVMatrix(marker.transformMatrix);
        }
        lre.render();
}
```

In init3D method is happening the 3D modell and the indicator inicialisation. The server obtaining the parameters from the portal and during the communication with user it's happening the data exchange. If it is included, we use the texture for the modell. The role of loop method is the marker recognising, the modell attached is handling the linear transformations.

5.   AR in education

AR is likely to be a new form of demonstration where no need to have any physical model presented, hence it should be available for students at home (only a printed AR marker, a webcam and a computer with internet connection are required). [8] AR books, AR development and logical games are just about to appear in education as below.

The usage of AR-technology could be inserted in many subjects i.e. maths on the lessons about geometry, or with 3D representation of cells in biology, [9], in chemistry displaying molecular structure [10] in PE a team sport simulation can be established. Additionally, any subject can be more colorful, more interesting and interactive.

Furthermore education may profit from AR development or logical games [11]. At computer science lessions students can familiarise themselves with the background of AR and they can create their own AR projects.

For instance, beginners can create their own 3D pop-up books at ZooBurst. After having registrated, storytellers can create their own world in which their stories can come to life. An AR-marker can be assigned to the virtual book that helps the phisical book to become lively. (www.zooburst.com)

On the next level, students may construct a 3D model with 3D editing tools and an AR-marker accompanied by their own AR source codes.

6.   AR books

A study by Marshall et al. has revealed that people still prefer phisically existing books since they favour physicality, transportability, flexibility, robustness etc. [12] On the other hand digital media offers the possibilities of interaction. Digitally augmenting and enhancing real books gives the advantage of both. With AR technology books can be supplemented with additional visual information uniting pictorial content of a real book with virtual elements that add educational content. The user can switch between pages by the physical action of turning the page. Certain

pop-up books enhance the interaction by allowing the user to push, pull, roll, and press different interactive features present in the book.

AR-books have also caught the attention of teachers because of the opportunities for interactive display, simulation, three dimensional graphic, sound and animation which could help understanding complex processes or the sight of 3D models.

The topic covered in „magic book", is not a recent innovation since this type of book was discussed at the Billinghurt and Kato's activity in 2001. [13] It is also important to mention Wellner's Digital Desk that is one of the foundation-stones in this field since it has united the virtual and phisical world in the beginning of 90's. [14]

Traditional books can be complemented with AR technology by augmenting them with 3D objects or animations. Heroes of the plot may come alive as they can be perceived in two or three dimensions while playing some animation.

7.   AR assistance on 3D modelling course on ELTE IK

Using books with AR technology is still unexpected novadays, but the first steps have been made. On ELTE Informatical Department during the 3D modelling course for teachers help has been made a halv virtual, halv analog, printed coursebooks.

A course „3D Modelling with Maya" was started in 2009-2010, where the students could get a general idea about 3 D modelling, in first hand about Autodesk Maya (http://autodesk.com/maya) software. During the courses they become acquainted with modelling in 3D, but we had difficulties with stundents differents points of view. Are books about this subjects, but because the visualisation is only in 2D, the pictures understanding is not always unambiguous. Fortunately during the planing this course we had the AR portal and theoratical skills and we could develope the AR coursebook and the students could use after they had the basics.

„Using the coursebook the students can follow a real 3D modell creation step-by-step, because during the course not the start or the goal is important, but the road and the knowledge they get. Because of this if they miss any part of 3D modelling can't understand the complete proces and it is difficult for them to follow the instructions. To make spectacular illustrations in book, we used AR markers and if the students hold these in the front of computer's camera they could see, rotate the modell actual estate and for this they needed only a computer. Making this coursebook wasn't necessary, but is worth it the time we invested. In our case we had to save each step from a a3D modelling in a right format and uppload on AR portal, place a marker and attach the markers to the text in coursebook.
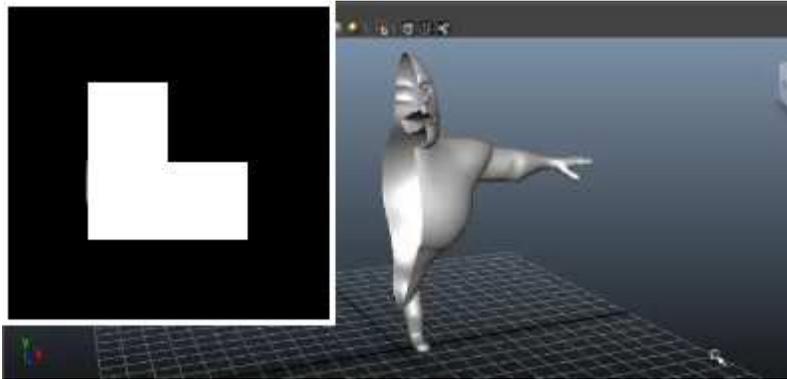
figure 6. A part of the course book: Step 12. – Mirroring of model

Of course this book, or the course are only the top of the iceberg, we could mention many examples where books like this could be used. Presentations, in real life invisible molecular constructions, atomic formulas, and cartographial modells in a few minutes only could be demonstrated.

8.   Virtual university building

Not only the coursebook was the result we made, we have another outcome: the complete 3D modell of south building of Lagymanyosi Campus, from outside and inside. The most difficult was the building creation. After we obtained the achitectural plains and made the building, painted the walls, made the textures and when the modell was ready, it was necessary the interaction. The idea was suggested from a final thesis about university, wich wanted to make virtual the university, helping the orientation in building.

With AR technology we made a more complex functionality. The entrance we could control by markers, change the modells face with our and imagine we are who are the main character in this virtual world. It was possible to attach episodes to this world, like doors opening, light swicht on/off etc.

This modell has been used for presentations in a folder with AR marker during an open day at university, when the visitors receive and holding in the front of a camera the building rise from the prospect.

9

9. Chemistry AR note

9.1. Creating of AR-exercise book and preparation

We decided to create an AR technology-based high school lesson. In our mind it should be an AR-excercise book that can be used at home. The basic idea was to integrated AR-markers into the selfmade lesson plan.

Our choosen subject was chemistry. One of our reasons isthat, among student – according to our survey and statistics of continuing education – it is one of the subjects that achieving the title of the „most unpopular subject" and besides, students perform at a very low average. It is a fact that in Hungary over the past few years just a few students majored in teaching chemistry at any of the teachertraining universities. Besides, 2011 is the International Year of Chemistry, so we would like to popularize chemistry and raise itsimportance.

During the design of the project we throught that students surely would be open to innovations and they would gladly try AR-books, even if these are releated to a chemistry curriculum. The overall oppinion of the chemistry teachers was that it would be in inself a good result if children took out their chemistry books at home. The poor performance in this subject is not only due to its difficulty, but in the fact that it is not compulsory to graduate from chemistry, so many of the students don't even try to understand and learn it.

After we choose the subject we had to decide which part will be processed. The main aspect was that proceeding of choosen part of curriculum need dimensional illustrations, animations and experiments. The choice was made on the structure of molecule, which is anyway not an easy topic for students. It is a part of curriculum class 9. [15]

Our goal was to represent a succesful example for AR technology – and combine a classic student book with the new 3D modelling. We split the students in 2 groups and only one of them got the AR coursebook, the other group received the coursebook without AR version. Our hypothesis was the students who study from books with AR will get better results during the tests comparing with earlier achievements and will have better outcome comparing with stundents who are using coursebooks without AR.

In preparation and testing the AR exercise book the chemistry teacher, Molnár István was a greate help and assistance, he wrote the chemistry curriculum and test for the exam.

The finished course had the following subjects:

The basic skills about molecules formation, what is covalent bound, electron transfer, molecule structure, σ-bond, π–bond, primary and secondary bonding (polar an nonpolar bond). One of main task was to present the molecules formation, how the molecular orbitals are working, the linear, tetragonal, pyramid and V-systems.

We expanded the elaborate curriculum with 7 AR-marker, five of them be ordered to a 3 dimension illustration of a strukture of molecule, one of them be attached to an animation and lastly one be ordered to a video of an experiment.
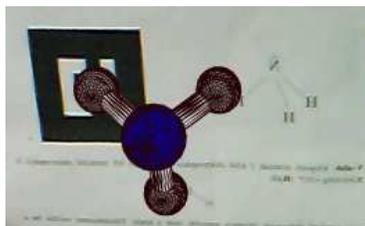
figure 8. AR-note NH_3
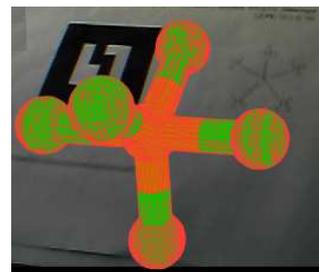

figure 9. AR-note AR marker of PCl_5[1]

figure 10. AR-note PCl_5

It was very important for us to find out if these illustration will be helpful during the understanding of the new concepts of the curriculum to motivate students preparing at home and to know if the the complete rotating 3D molecular structures can be understand by students. After we made the curriculum with AR-marker and 3D modell, animation and video, we ordered the AR-marker to the object on AR-portal what is made by ELTE T@T labor.

9.2. Use of AR-note

The „ready to use" notebook was tested by us and then we could start the school test too. In the experiment participated two secondary schools: the technical college János Neumann and the secondary school Ferencz Rákóci II.; with 184 students from class 9 and 10. Majority of chemistry teachers who were contacted by us welcomed inquiringly the preapered material. Unfortunatelly not all of them could take part in the experiment because they didn't teach the choosen topic or hadn't got the neccesery classes. Were many teachers who asked for the material in order to use it in the future.

The teacher's orientation was followed by introduction for students. We did a survey about web camera using by students.

We were lucky because in each classroom almost every student had a web camera, and it was easy to split them in 2 groups: an AR group and a control group. Students in first part of namelist were divided to the AR-group. Students, who don't have a webcam, can use it in the school.

For curriculum we needed two lesson hours, in the beginning the students watched a presentation about AR technology and about how to use the received AR exercise book at home. Lesson was held in customary form apart from the first 10 minutes of lesson. The members of control group received the exercise book without AR codes version. We told them next time they will get the exercise book with AR codes. During the lessons the teachers haven't used the AR manuals, they thaught in usual way. After they finished with the courses, the students could keep the manuals and they could prepare at home for the next hour examen.

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[1] http://arportal.elte.hu/arkemia/bin-debug/arkemia.html

On the next lesson was followed a test with 11 tasks in 20 minutes. In test we put three questions specifically about moleculas spatial post and hopefuly the AR modeling helped the understanding.

94 courses books have been divided and 90 students were tested.

9.3. Results

We had right in our hypothesis: the members of AR group had better results in test. The experimentwas made at the end of first semester and in this case we could use the 1th semester notes. The rating was made in five numbers from 1 to 5, the worst was number 1 The number of studens was approximately the same in both groups. The AR group average in chemistry was 2,44; the control group had 2,64.The average of test was 3,2 at AR group and 2,62 at control group. We observed that the control group had almost the same results, the AR group developed significantly (0,76).
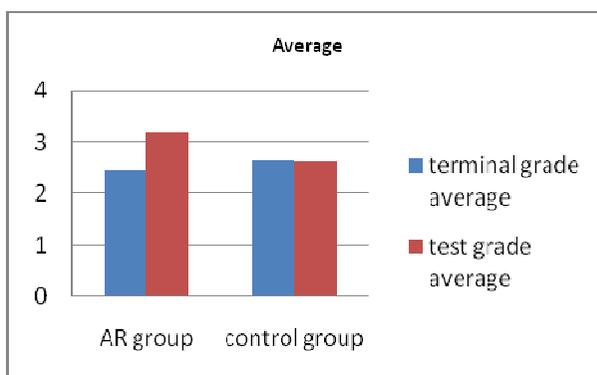

figure 11.: Test's result in two group

The members of AR group had the following results: 60 % had better notes, 38 % the same and only 2 % had worse notes comparing with the notes before test. The results at control group were more ambivalent: 27% with better notes, 42 was the same and 31 % had worse notes.
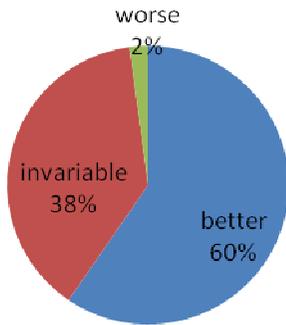
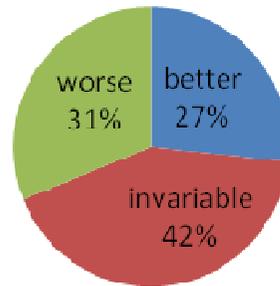figure 12.: Test's result of AR group copared to average of chemisty

figure 13.: Test's result of control group copared to average of chemisty

We observed the results for3 test with 11 questions, because it can be used significantly for AR technology results. In the following you can see the right answers from stundents in different groups:

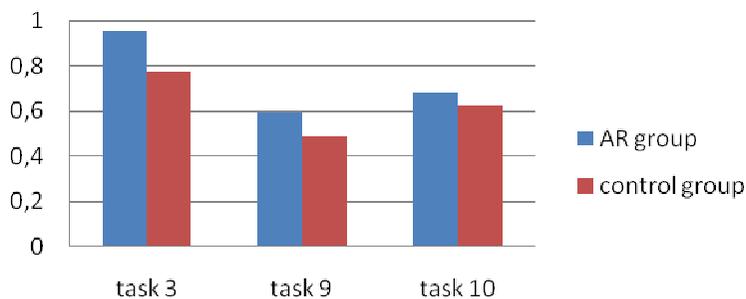| Group/Task	Task number 3	Task number 9	Task number 10
AR group	95,74	59,57%	68,09%
Control group	77,78%	48,89%	62,22%
Table 1.			

figure 14.: Result of three specifically questions

On the whole our experiment was successful. Both teachers and studens had positive opinions about AR manuals, they were intersted and would use in the future.

A few opinions and feedbacks from studens and teachers:

„*When I told to others the possibility to create a computer visualised geometrical structur, possible to rotate, visible at home- computer, everybody was very excited waiting for next presentation. When the time arrived, we could watch the ELTE south building in 3D conjugated with*

AR marker. At presentation many haven't understand how this is working and later more were interested about during the courses. After our experiences the modeling working at home, sometimes with a very strong light wasn't clear visibility or with a slow internet connection the rotation was discursive.

After test I asked the students who got AR manuals, what they see the models and the material. For them it was important the fact the subject was collected and the models were better to understand like the pictures on board or in the books.

A few students said the same about the pictures, but after their opinion it is necesarry the explication part, without that it would be difficult. None of them had negative opinion.

From teacher's opinion, naturally this „experiment" is comming with more work. Collecting and made the right pictures, it takes time, but the results compensate for long working hours. In average 3-4 tenth percent evoluation was made between on a test average and a termin note.

I would work (and planning to work) with this technology and I can imagine a coursebook with it. The students could use not only at home, but the teachers could improve the presentations and teaching in classroom with a 3D picture.

In conclusion: I can't tell anything negative about. Nobody needs new computer knowledge for using . I think a digital coursebook could help to improve students approach fot natural science." (István Molnár, chemsitry teacher)

„ I think is more easy to learn with this..." (student)

„It was very interesting for me, it would be great if we could have something similar in a few subjects. We could made funny things with... Sometimes it was difficult for computer to recognise the picture, but it was fun!" (student)

„Basically I dont like chemistry, a long time ago I loved. First I didn' liked I was in the group who got some extra home work, but when I found out what is all about I get curious. And I liked ☺(student)

„ I got 2 for my test!!! Now my parenst let me for party ☺ Let's have this AR thing again" (student)

In our future plans is making a 3D model of molecula construction for high school curricula, even in collaboration with students and with AR codes; this could be more interesting, t.ex the molecula construction picture in 2D or the atomic formula construction. These could be used at a AR card at home or in school. Later even a possible chemistry book could be created.

This project can be extended for many subjects: mathematics, biology, and physics.

10.   Summary

In our paper we introduced the relevance of augmented reality (AR) and presented how the technology works, showing some examples of popular products and the direction where it is heading. We described our own developments in this area, explaining the different modules of the AR portal and their use. We demonstarted some of the applications in university education

and then ellaborated on an experiment within secondary school. Our present findings so far convinced us that AR technolgy could be a very good practical extension to textbooks and exercise booklets, since they give virtual hands on experiences to understand better the models within learning context. Our positive results convinced us to continue with our research in this area.

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