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Applying Augmented Reality in Engineering Education to Improve Academic Performance & Student Motivation*

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Students starting at university are accustomed to using the latest generation of devices and technology for communication, leisure and work. All technological progress allows for the use of innovative learning tools in education, causing significant changes in teaching methods and the students' learning processes. Augmented Reality (AR) in education is an emerging area, so this paper analyses how this technology influences academic performance and encourages student motivation. We are starting from the hypothesis that the use of didactic material based on AR technology will improve motivation and the academic performance of students, so new didactic material has been developed using AR to explain the contents of standard mechanical elements. This research yields results that indicate how engineering students obtain better academic results and are more motivated, when the new generation of technological tools is incorporated into the learning process. Twenty five first year students studying for a Mechanical Engineering degree used AR technology to assist them in the subject of graphic engineering. During the study, a control group of twenty two fellow students used traditional class notes. All these students took an exam and two surveys to give feedback on the teaching material: one for finding out the effectiveness and efficiency of the material itself, together with the level of student satisfaction; another for assessing the level of student motivation when using the technology available during the study. The results showed a significant statistical difference between their academic performances, proving to be higher in the experimental group; this group also showed a higher level of motivation than the control group.

Keywords: augmented reality; engineering education; standard mechanical elements; motivation; academic performance

1. Introduction

In a global report on education submitted by UNESCO [1], it was pointed out that a virtual learning environment has become a brand new way for educational technology to offer teaching improvements in institutions across the world. In this report, a virtual learning environment is defined as an interactive program, focused on learning that has integrated communicative capabilities. Virtual learning environments are a recent innovation as a consequence of the convergence between technology and telecommunications that has intensified over the last few years.

Informative and communicative technologies (ICT) are widening communication possibilities and are therefore generating new mechanisms and capabilities to enable an expansion in knowledge. In the field of teaching, it is causing an important change in didactic methodologies and interpersonal relations in the classroom [2]. The interactivity provided by some technologies is one of the main pillars of social change that has recently taken place. Young people regard these technologies as a social, leisure and work tool as they use it in their social and learning environment [3].

ICT are unavoidable in all aspects of human life: science, economy, social life, information, sports and family. Without them it would be hard to achieve the effectiveness, precision, comfort and quick access to widespread information to which we are accustomed. Technology has become the real engine of learning, which is an outstanding truth in the educational sphere, since technological resources have been used by teachers to facilitate students' learning [4]. Every technological development allows for the use of innovative learning tools in education, causing significant changes in teaching methods and students' learning processes [5]. The teaching model is being modified, as well as the role of teaching staff, which changes from being the only source of knowledge into a guiding and advising role [6].

This recent technology, "Augmented Reality", referred to previously as AR, has been applicable to learning and entertainment purposes, or "edutainment" [7–9].

Azuma [10, 11] indicated that AR has great potential in many fields. They highlight applications, (APPs), in fields such as; military [12], medicine [13], engineering design [14], manufacturing,

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maintenance and repair applications [15] and psychological treatments [16], amongst others.

According to The New Media Consortium's 2011 Horizon Report [17], augmented reality is becoming a technical trend in higher education and is just two to three years away from making the blend of technology, virtual and real, which is expected to achieve mainstream use in education through augmented reality textbooks (augmented books). In the near future, this technology will be used substantially, as many aspects of the understanding of augmented reality are being discussed in most congresses and conferences, and where the progress made in this technology by researchers and professionals is being demonstrated and evaluated.

This paper shows how an AR application uses an Augmented Book which is used as an interface to assist in teaching Industrial Engineering. Whilst using the Augmented Book, virtual models appear over the pages. The Augmented Book is able to help mechanical engineering students learn sketching, designation and normalization of mechanical elements. These themes are common in subjects such as Graphical Engineering, Machine Design and Mechanical Technology, amongst others. Students need to master these fundamental subjects to be successful in academic performance.

1.1 Aims and research questions

The main aim of this project was to develop an innovative AR system, allowing students to learn standard mechanical elements in an interesting way. The technology is quite remarkable because it enables learning in such a way that it is as if the users had real objects in their hands; it is innovative because, as far as we know, there is no other AR system that has been developed for this purpose. A pilot study was introduced to mechanical engineering students with the objective of comparing the acquired knowledge, the use of this kind of material and technology, as opposed to traditional class notes. Besides this, the usage of the AR book was evaluated, bearing in mind different aspects [18, 19]; *technical aspect*, *orientation aspect, affective parameter, cognitive aspect* and *pedagogical aspect.* The study explores the impact of AR technology as used for engineering students, measuring usage factors (effectiveness—efficiency—satisfaction), besides which motivation and learning were measured. It seeks to answer the following research questions:

- How did 3D Simulation-based Learning affect the students' understanding and the application of what they learned?
- What are the levels of satisfaction and motivation of students with regard to the use of augmented reality material?
- Is AR technology, based on didactic material support, efficient and effective for learning?

2. Frameworks

2.1 Augmented reality and its application in education

Augmented Reality is a recent technology that is similar to the Virtual Reality (VR) paradigm. As is the case for Virtual Reality, several formal definitions and classifications for Augmented Reality exist [20]. AR combines 3-dimensional (3D) computer-generated objects and text superimposed onto real images and video, all in real time. Azuma [10] defines AR as a variation of Virtual Reality. VR technology completely immerses the user in a synthetic environment. While immersed, the user cannot see the surrounding, real world. However, AR allows the user to see the real world with virtual objects superimposed or combined with the actual environment. Therefore, AR complements reality, rather than completely replacing it. With AR applications, it is possible to show the user a common space where virtual and real objects coexist in a seamless way. From a technological point of view, AR applications must fulfil the following three requirements [11]; the combination of real and virtual worlds, with real time interaction and accurate 3D registration of the virtual and real objects. Augmented Reality applications can be used in several setups including monitor based systems, see-through and video-see-through head mounted displays (HMD) as well as projections based on spatial augmented reality.

As Billinghurst [21] and Shelton [22] state, although AR technology is not completely new, its potential in education is just beginning to emerge, therefore several European Union AR projects have been developed in order to improve the learning process and techniques in education [23, 24]. It can name some examples of teaching tools based on AR for primary education, (like the solar system and the life-cycle of plants) developed by The Mixed Reality Lab [25] at the National University of Singapore. This technology is based on 3D interaction, allowing the user to learn certain concepts in an easier way. Besides this, AR has many advantages over traditional manual-based and VR models in training and learning applications because users can see and touch real objects, being able at the same time to have an interactive guided support, which allows users to work at their own pace.

In university education, there is a shortage of teaching APPs based on AR technology. Outstanding work was developed by Kaufmann and Schmalstieg [26], who proposed a geometry application, together with Kaufmann and Meyer [27] who later developed an educational tool for explaining physical experiments. Applying augmented reality and its application can simulate physical experiments in a mechanical field, while Martin-Gutierrez et al. [28], proposed training as the way forward in improving spatial ability in university students.

The combination of AR technology with educational subjects brings about a new type of automated application for the enhancement, effectiveness and attractiveness of teaching and learning for students in real life. The technology provides a simple way to make progress in the field of teaching and in learning how to train in education. It promotes 'active' learning, both in the psychological and physical sense, encouraging users to have several thinking perspectives, which should set them up adequately for their daily activities [28].

2.2 Augmented Book Physical Interface

One of the most well-known AR educational interfaces is the Augmented Book, also known as "Magic Book", [29]. The Augmented Book uses normal books with AR markers as the main interface objects. People can turn the pages of the book; look at the pictures and read the text, without any additional technology. However, if they look at the pages through an AR display, they see 3D virtual models appearing out of the pages, thus introducing an interesting way for smoothly transporting users between reality and the virtual experience, using a physical object [30].

Tallyn et al. [31], makes a comparative study of a paper book, a multimedia CD-ROM and an AR book, concluding that the augmented book provides a flexible and easily approachable interface, aiding the integration of digital media into paper-based activities.

The "basic" Augmented Book experience only requires adding a webcam to a typical PC configuration and the proper software. Using the computer screen to visualize the augmented scene is a cost-effective and eye-catching alternative in the educational context, which is the idea presented in this paper.

Another kind of interface was used by Juan et al. [32], which was based on tangible cubes for learning varied theory through an AR system.

3. L-ELIRA: Learning industrial elements means augmented reality

The Augmented Book created to be used as didactic material has been named L-ELIRA, which is associated with an AR application for visualizing virtual content. This book may help mechanical engineering students to gain knowledge and learn how to sketch, also the designation and normalization of standard mechanical elements following ISO standardization international rules [33], ASME-ANSI [34–37], DIN regional regulations and UNE Spanish standardization rules [38–40].

These contents are common in subjects such as Graphical Engineering, Machine Design and Mechanical Technology, amongst others. Students should master these fundamental subjects to be effective academically. It is intended that this Augmented Book be used as an Industrial Engineering teaching aid, if changes to the validation study and common use are positive.

3.1 L-ELIRA application development

Applications based on AR may use different methods for introducing virtual objects into the real world (GPS, markers, inertial systems, etc.). For developing this work, BuildAR [41] has been used, as it supplies a graphic interface, simplifying AR APPs development without needing a library marker.

Accurate position and orientation tracking is required for the registration of virtual elements in the real world, so BuildAR uses a marker-based method and allows for the creation of markers using the 'Markers Generator', which proposes an external black cube in which the inner part can be stored in any way that the graphic user desires (Fig. 1).

Thus, BuildAR allows the creation of a personal library of markers for the orientation and insertion of virtual elements in the real world. In this way, the APPs developed through BuildAR require a webcam to capture the real world so that the snapshot recognizes virtual objects on the visible markers. Marker behaviour is similar to a barcode containing the attached information.

Programming skills are not required for BuildAR because it simplifies the implementation of files and markers. A 3D model or even an animation can be associated with the marker. There are up to 141 mechanical elements modelled (screws, shafts, axles, gears, belt wheel, sprockets, pulleys, couplings and bearings), four motionless machines and five animated machines (Fig. 2). One hundred and fifty different markers have also been created to be assigned to each element.

In BuildAR, interface markers are added so each is associated with a virtual model. We should bear in

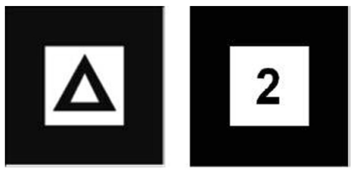

Fig. 1. Kinds of markers.

Fig. 2. Augmented information on L-ELIRA.

mind that 3D models were created through CAD programs with a predetermined size, making it necessary to adapt them to a scale and adjust them, so as to be viewed at the proper size in the real world (augmented reality). In the same way, it is possible to displace the 3D model with respect to the markers position, to any distance in any (X, Y or Z) direction. The scene developed is an XML file which contains links between the markers' files (*.patt) and virtual models (*.ive in our case) together with all defining parameters such as the marker size, scale values, rotation and displacement, etc.

3.2 Material and contents' description

The L-ELIRA interface is an Augmented Book consisting of two volumes of eight chapters: (1) Simple thread elements: bolts, nuts, studs, etc. (2) Non thread simple elements: Pins, cotter pins, washers, etc. (3) Security device, (4) Bearings, (5) Gears, (6) Spring, (7) Motionless Machines and (8) Machines in motion (Fig. 2). Each chapter has an introduction with the theoretical contents and the following technical card for each standard element.

The card contains information on use, rule number and elemental standard designation. Besides this, it also contains graphic information about standard representation, photorealistic images and a marker, which allows for visualization of the 3D standard element from any point of view, through augmented reality using BuildAR (Fig. 3).

4. Purpose of study: L-ELIRA learning

The purpose of this study is to find out and quantify the benefits of L-ELIRA on learning through didactic material, as well as knowing its effectiveness and student satisfaction regarding the learning process and AR technology, through a study of its use. Besides this, student motivation for learning with the technology will be measured.

Fig. 3. Technical card sample.

To analyze the impact of the educational content on students, we compared the knowledge acquisition and motivation of an experimental group, using the new L-ELIRA material, with another group which used more traditional hand written class notes. In the study of its use, several aspects were considered, such as the effect on computer and student interaction.

5. Methods

5.1 Participants

The study included forty seven first year students of mechanical engineering from a University in Spain, aged between 17 and 21 years, (with an average age of 18.7years, SD=1.1), where twenty five of them used L-ELIRA, while the other twenty two used traditional class notes.

5.2 Design and procedure

The experiment took place during the last six weeks of the second semester of the 2010-11 academic years. The teacher explained the mechanical standardization as in previous years. Students of both groups participated in normal activities in the classroom; the only difference was that a group of the experimental students had the L-ELIRA available to study with at home and the control group students used their traditional class notes to study. Students who took part in the study had partially passed the subject and only required one last evaluation on the standard elements to pass the subject completely. The students' interest in passing this last exam completely was a clear indicator that they probably studied responsibly. When the six week period was finished, all the students (forty seven of them) sat one last exam to evaluate their knowledge on mechanical standardization and the R-SPQ-2F questionnaire [43], was given to them for completion. This allowed for the assessment of the students' opinions on their motivation and strategies for learning. A second questionnaire was given to the students belonging to the experimental group which sought to measure the levels of effectiveness, efficiency and satisfaction of the use of L-ELIRA's, as well as augmented reality technology.

5.3 Measure of learning

In order to analyse the impact of the educational content on students, a last test was taken which evaluated up to a 10 point maximum. The results obtained may be seen in Table 1.

The exam was passed when a five point score was reached. In the group studying with L-ELIRA, there were just five students where 20% failed, whilst in the traditional class note group, there were eleven students and 50% failed to pass the test (Fig. 4).

5.4 Measure of usability and motivation

The measures of usability are more reliable when psychometrically validated questionnaires are used. However, it is difficult to get hold of the types of questionnaire which can be adapted to this kind of experiment. In our case, we designed a survey with questions specifically for our experience, based on Hornbæk's [42].

These defined the components of usability according to Bevan [43]:

- Effectiveness: "accuracy and completeness." Error free completion of tasks is important in both business and consumer applications. We can

Table 1. Average rating and standard error

	Mark (Std. Desv.)	Std. Error
Experimental Group (L-ELIRA) N = 25	5.84 (1.54)	0.31
Control Group N = 22	4.5 (1.84)	0.39

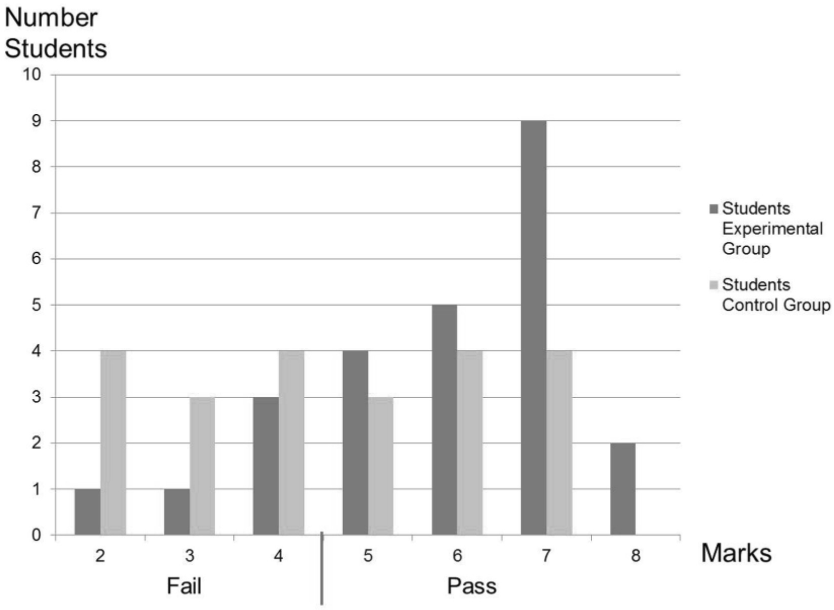

Fig. 4. Marks obtained by students.

say that the effectiveness of a product depends on how accurately it carries out the tasks and achieves the objectives for which it was designed.

- Efficiency: "resources expended." How quickly a user can perform the task which is critical for business productivity.
- Satisfaction: the extent to which expectations are met. Satisfaction is a success factor for any product with discretionary use; it is essential to maintain the workforce's motivation.

A survey was designed to measure the effectiveness of L-ELIRA, as well as the efficiency and satisfaction in the use of AR technology. The survey was designed with the intention of evaluating standards on APPs based on AR technology. Questions were set in two blocks: effectiveness of the developed material and the efficiency and satisfaction with the technology (Table 2).

The measurement of a student's learning process was carried out using a two factor scale designed by Biggs, Kember and Lenng [44]. This R-SPQ-2F questionnaire contained twenty items which reflected the motivation and learning strategies of students. Biggs pointed out that the teacher may use two factors (significant and superficial) to evaluate their own teaching and the learning approaches of their students. This structure relates to both studying attitudes of motivation and strategy, the former including items related to motivation by way of a more thorough study of the student's interest and efforts. The latter consists of items related to motivation, as in looking for a more superficial approach to studying, focusing just on passing the subject with the least possible effort. Besides this, a questionnaire was given to measure strategy and motivation, as half the items were related to the student's motivation, whilst the other half related to study approaches or strategy. With regard to both factors, we can identify two main scales (motivation and strategy): Deep Approach (DA) and Surface Approach (SA), with two subscales for each one: the first two refer to Deep Approach, Deep Motive (DM) and Deep Strategy (DS); the other two, Surface Motive (SM) and Surface Strategy (SS), refer to Surface Approach.

Following Biggs' instructions for tracking the teaching performance after the innovation procedures, it's advised to develop an analysis through the two factors method (DA and SA) but analysing subcomponents as well might be of further interest (DM, DS, SM and SS). Both strategies describe the way students engage in the task itself. The achievement strategy explains how the students plan their approach to the task and for how long. This can be seen in annex 1.

In order to make a reliable estimation of the results, eight or ten participants are necessary because larger samples give a more significant conclusion when evaluating the rate of success [43]. In our study, the evaluation of the effectiveness of the material, as well as of the efficiency- technology satisfaction, (as previously mentioned), has been done by all students belonging to the experimental group, but questionnaires regarding motivation and strategy were given to both control and experimental groups. In this survey, students were supposed to use a five level Likert scale to provide their opinion.

Table 2. Effectiveness, efficiency and satisfaction survey

	A.—Effectiveness material	**Mean value (std. error)**
A1	Augmented textbook is nicely presented	4.80 (0.08)
A2	Suitable chapter and contents structure	4.76 (0.77)
A3	Book's A5 size adequate for virtual content manipulation	3.88 (0.1)
A4	Augmented reality application is stable (bug free)	4.84 (0.1)
A5	No additional material needed for studying contents	4.84 (0.1)
A6	Teacher explanations are easier to understand through the Augmented Book	3.44 (0.3)
	B.—Efficiency and technology satisfaction	**Mean value (std. error)**
B1	Augmented textbook is easy to learn	4.84 (0.04)
B2	I would rather choose traditional class notes over new augmented textbook	1.00 (0.0)
B3	Proper 3D figures visualization with no definition problems	4.88 (0.1)
B4	No image leaps when manipulating virtual objects	4.72 (0.2)
B5	I think this augmented textbook will help me perform better in an exam	3.72 (0.2)
B6	I like using this Augmented Book at home by myself	3.88 (0.2)
B7	Augmented Reality technology has been interesting to use with this didactic content	5.00 (0.0)
B8	Augmented Reality is useful for studying this didactic content	4.12 (0.3)
B9	How do you value the Augmented Reality technology working with three-dimensional model? (1 bad–5 excellent)	3.96 (0.5)
B10	Technology Augmented Reality technology seems interesting	4.48 (0.1)
B11	Technology Augmented Reality technology seems useful	4.40 (0.2)
B12	Object use and manipulation with AR technology is frustrating	1.36 (0.2)
B13	Overall opinion of the experience is excellent	4.32 (0.3)

6. Result

6.1 Learning's data analysis

To measure learning, a statistical analysis was carried out to identify the significant differences between the results obtained by both groups. *T-Student test for independent samples* was used to compare average values obtained in each group. Considering null hypotheses H_0 there is 'no difference between results obtained by both groups' which means average marks obtained by both groups were similar.

Academic results are statistically significant when comparing the results from the experimental group to the control group (t = 2.708, p-value = 0.009). P-values are well below 1% of statistical significance, which indicates that students have a probability of over 99% of obtaining better results using L-ELIRA. The Kolmogorov-Smirnov Test compares the distributions between the two samples. This test

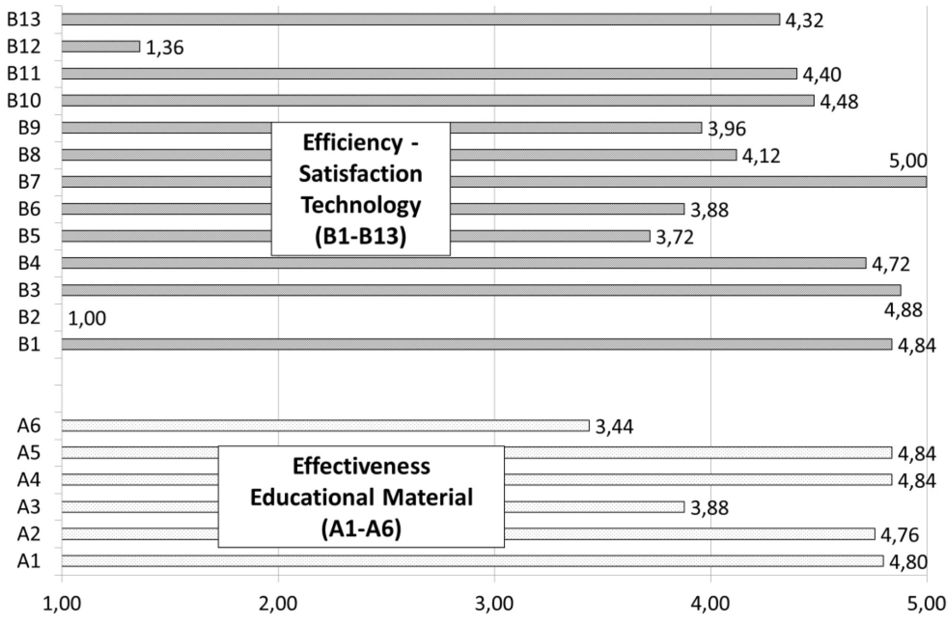

Fig. 5. Usability components rating chart.

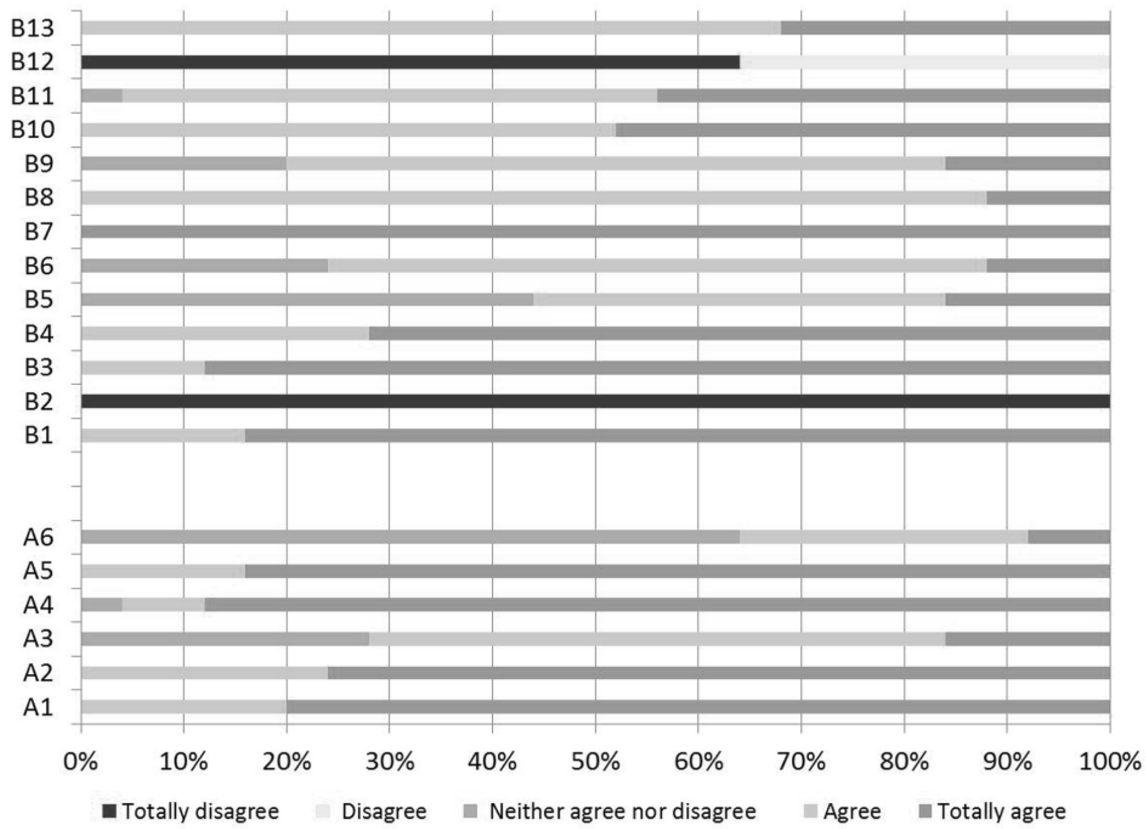

Fig. 6. Answers classification in usability questionnaire.

is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,458 (K-S = 1.567, p-values = 0.014). Since the P-value is less than 0.05, there is a statistically significant difference between the two distributions at 95% confidence level.

6.2 Result survey

The usability survey shows that all students using L-ELIRA expressed a highly positive attitude with regard to the material content and technology. The material and content have been very well received; as the measure of effectiveness gave a good result (see Table 2 and Fig. 5).

In the first set of answers, students considered the L-ELIRA material carefully presented with an attractive design of its contents and an adequate structure of the chapters and contents (sample of technical aspect). A significant number of students thought that the book size was suitable for the easy manipulation of virtual objects and text informa-

Table 3. Statistical summary (t-test and p-values) for motivation, strategy and approach for each of the R-SPQ-2F scales

Main scales	**Mean (SD) Experimental Group[1] (N = 25)**	**Mean (SD) Control Group[2] (N = 22)**	**T-test and P-value**	
Deep Approach	3.51 (1.44)	2.40 (1.32)	**8.68 ***	p = 0.0
Surface Approach	1.97 (1.43)	3.47 (1.25)	**–11.98***	p = 0.0
Subscales	**Mean (SD) Experimental Group[1] (N = 25)**	**Mean (SD) Control Group[2] (N = 22)**	**T-test and P-value**	
Deep Motive	3.94 (1.51)	1.76 (0.98)	**12.92***	p = 0.0
Surface Motive	1.40 (0.75)	3.49 (1.28)	**–15.45***	p = 0.0
Deep Strategy	3.09 (1.24)	3.03 (1.31)	0.31	p = 0.75
Surface Strategy	2.55 (1.69)	3.44 (1.22)	**–4.59***	p = 0.0

[1] Number response 125; [2] Number response 110; *, P < 0.001.

tion tracking (sample of orientation aspect). 95% of them pointed out that the APP did not obstruct during study and 36% of them also thought that using L-ELIRA made following teacher instruction easier, while 64% of the students did not comment on this aspect (sample pedagogical aspect). See Fig. 6.

Regarding the effectiveness and satisfaction of AR technology, all students agreed that it was easy to learn and use (affective parameter). Absolutely all of them (100%) preferred the new notes with 3D additional information over traditional ones. Also, all of them think it would help them manage their performance during exams. 56% of the students regarded the use of the application whilst at home as very positive, while the rest, (44%), had no preference over class or home use. All the participants regard AR use to be very interesting when didactic purposes are considered and that it functioned perfectly with 3D models. The overall opinion of the students was that studying and using AR was an excellent experience.

Referring to motivation, Table 3 represents a summary table for both the experimental and control groups, containing the mean scores with SDs and T-Statistics for all of the scales in the Study Process Questionnaire (R-SPQ-2F).

The five scales reveal a statistical difference between both groups. Deep Approach ($t = 8.68$, $p < 0.001$) and Surface Approach, ($t = -11.98$, $p < 0.001$) which underlines the differences between both motivation and learning strategies. The experimental group was more motivated than the control group who just studied and whose only interest was to pass in the subject. On analysing the sub-scales, the results were similar. Deep Motive ($t = 12.92$, $p < 0.001$), Surface Motive ($t = -15.45$, $p < 0.001$) and Surface Strategy ($t = -4.59$, $p < 0.001$) reveal that the experimental group was more motivated than the control group and carried out the study with more effort and interest. Besides this, the strategy for passing the subject has been quite different.

Deep Strategy (DS), indicated that there was a significant statistical difference between both groups, ($t = 0.31$, $p > 0.05$) which meant that the strategy for passing the subject was different for the experimental group who focused on learning, while the control group used the data and memorized it.

7. Conclusion

L-ELIRA material consists of an Augmented Book intended for the study of mechanical engineering subjects and for those seeking distance learning and more control over the learning process. The research carried out in this work succeeded in developing teaching material L-ELIRA, that consist of an Augmented Book intended for the study of mechanical engineering, moreover to test this learning material in relation to the knowledge and motivation acquired by students using such material and augmented reality technology.

Students are comfortable working with a 3D graphics tool that did not have to be previously formed and they consider that augmented reality tool to use L-ELIRA is an intuitive application that does not need cognitive learning. This reduces the cognitive overhead needed for its use and allows us to focus attention on the acquisition of knowledge. Students using AR based material have better academic performance than those using traditional class notes, in fact, 80% of students using the new AR based material passed the final exam while only half of the students using traditional class notes were able to do this. Students consider L-ELIRA as a good didactic material which has relevant content and well structured. They indicate that this fact allows use it to learn autonomously. In addition they value that does not require use of additional resources (financial or Internet connection), only requires a personal computer and a webcam.

Statistic study carried out underlines the differences between both motivation and learning strategies. Results reveal that the experimental group was more motivated than the control group and carried out the study with more effort and interest. Besides this, the strategy for passing the subject has been quite different, the experimental group who focused on learning, while the control group used the data and memorized it because your only interest was to pass in the subject.

In Summary, the use of L-ELIRA encourages students to study thoroughly and more enthusiastically and assists them in focusing on the didactic contents, rather than just passing in the subject.

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Annex 1

1—this item is *never* or *only rarely* true of me	2—this item is *sometimes* true of me	3—this item is true of me about *half the time*	4—this item is *frequently* true of me	5—this item is *always* or *almost always* true of me

	Motivation and Strategy. Revised Study Process Questionnaire (R-SPQ-2F)	**1**	**2**	**3**	**4**	**5**
DM-DA	C1. I find that at times studying gives me a feeling of deep personal satisfaction.					
DA-DS	C2. I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied.					
SM-SA	C3. My aim is to pass the course while doing as little work as possible.					
SA-SS	C4. I only study seriously what's given out in class or in the course outlines.					
DM-DA	C5. I feel that virtually any topic can be highly interesting once I get into it.					
DA-DS	C6. I find most new topics interesting and often spend extra time trying to obtain more information about them.					
SM-SA	C7. I do not find my course very interesting so I keep my work to the minimum.					
SA-SS	C8. I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.					
DM-DA	C9. I find that studying academic topics can at times be as exciting as a good novel or movie.					
DA-DS	C10. I test myself on important topics until I understand them completely.					
SM-SA	C11. I find I can get by in most assessments by memorizing key sections rather than trying to understand them.					
SA-SS	C12. I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.					
DM-DA	C13. I work hard at my studies because I find the material interesting.					
DA-DS	C14. I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.					
SM-SA	C15. I find it is not helpful to study topics in depth. It confuses and wastes time, when all you need is a passing acquaintance with topics.					
SA-SS	C16. I believe that lecturers shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined.					
DM-DA	C17. I come to most classes with questions in mind that I want answering.					
DA-DS	C18. I make a point of looking at most of the suggested readings that go with the lectures.					
SM-SA	C19. I see no point in learning material which is not likely to be in the examination.					
SA-SS	C20. I find the best way to pass examinations is to try to remember answers to likely questions.					

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