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Teaching Augmented Reality

Abstract: In this chapter, we present a brief description of the concepts that delimit the teaching/learning process of the subject of Augmented Reality and Accessibility, a subject provided in the degree of Computer Engineering at the University of Oviedo (Spain). This includes the requirements needed to achieve a better comprehension and the competences established by the students, a description of the methodology used in this dynamic and participatory process by the student and the technological support used to achieve the goals of the course, based on Bloom's model. Finally, it is also presented the model used for the evaluation process applied in this course, which combines both individual and group assessment activities, with cooperative evaluation from the teacher and the students.

Keywords: Educative models, assessment, evaluation and feedback, Augmented Reality, accessibility and usability, Interaction and Multimedia, mobile device.

1. Introduction

There is no doubt that Computer Science has become a part in our everyday lives making it more comfortable, practical and efficient. Computer science has made work and communication a lot easier since it is complicated to find a field where Computer Science is not present. It has even changed some of the behavior of society, as seen by the social media. The Internet has also shaken up the way of making several daily activities, from reading the news, looking for information of interest, communicating with other people, checking flights, timetables, completing formalities, to obtaining complementary information about some component from the real world, etc.

In addition, the increasing evolution of technology has allowed to convert mobile devices into powerful handheld minicomputers like smartphones and tablets, that nowadays offer big services such as faster access to the Internet, powerful photo and video cameras, instant communication, chat and many other features that make them sensible to the context such as location, motion, direction, compass, etc.

Therefore, the access to technology is a decisive factor when designing or developing an application, however, it has also established the possibility of de-

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signing and developing simpler applications making the most of the potential of the output devices.

In just a few decades, the supply and demand of applications has substantially evolved; from typical desktop applications in the 80s – students then were prepared to build computer programs so that one user interacts with it. During the 1990s, this scenario changed into web applications based on server, that is, many users doing the same tasks at the same time – students then were educated to build applications that would support large amount of users at the same time, transactions, distributed computing, etc. Nowadays, with the web 2.0 challenge of concentrate the applications in the user, the student must be prepared to develop applications to reach its proper display, use and access through different devices – improved applications that take advantage of the potential of the output device.

The development of Augmented Reality applications is included in this scenario, that is, applications sensitive to the context with capabilities of identifying locations, of recognizing and monitoring markers, images and real places, in order to adapt the display of digital elements of information – text, images, 2D, 3D, videos, etc. – within a specific situation of the user's context and location, adapting it to the user's environment and vision.

The study programs of courses in the Computer Science degree have had to go hand-in-hand with technology's evolution. The acknowledgement of this scenario meant a constant challenge to adapt and update the study programs in order to include new contents in the courses. That is the case of the subject of Augmented Reality and Accessibility, which emerges precisely in this evolution process, planned to educate students in the design, implementation and assessment of applications that would incorporate rich artificial content in real-world scenarios, and them are both usable and accessible, providing students with timeless structural contents, but at the same time encouraging their interdisciplinary skills and making them aware of the need to design applications focused on improving universal access, that is, including those with any physical and/or cognitive limitation.

2. The Subject

The subject of Augmented Reality and Accessibility is part of the study area of Interaction and Multimedia, and is taught in the fourth year of Software Engineering degree at the University of Oviedo as part of the Computer Training and Complementary Technologies module.

The course has two main goals: that students would gain long-lasting knowledge about the fundaments of the course as well as other related aspects, and that they would acquire skills to select tools and technologies that would allow them to design and develop small projects planned to promote the access to additional information. This additional information would improve the experience and life of the users in general, especially to those with cognitive limitations or those with any disability. It would offer the necessary support to these users so they would have actual equal opportunities, that would consider adaptation processes and techniques to their needs, and would add digital elements that would allow them to easily access additional information – computer-generated elements: text, images, videos, etc., resulting in a sense of coexistence of the real environment with the virtual world (cf. Wichrowski 2013) – more adapted to their needs.

The subject of Augmented Reality and Accessibility is designed so students would not only gain basic structural knowledge – concepts, features, algorithms, designs principles, different options of implementation, etc. – and elements of associated knowledge – accessibility topics, cognitive theory, natural interaction, usability and responsive design, etc. –, but so they would have a dynamic and participatory role in the teaching-learning process – designing, producing small projects, assessing and evaluating their tasks –, which means, giving them the opportunity to reinforce and go into detail about the contents of the course and applying them in the development of the activities planned for it.

The course is planned for a total of 150 hours, equivalent to 6 ECTS – European Credit Transfer and Accumulation System – that establishes 25 hours per credit according to the European Higher Education Area. These hours would be distributed as follows: 60 teaching hours – lectures or seminars, workshops, practices, tutorials and evaluations – and 90 hours of personal research – self-learning, study and the student's tasks and projects.

To measure the achievement of the proposed goals for the course, a set of competencies – that the student should acquire – were established on the verification report of the degree and documented in the teaching guide of the course:

1. Methodological competences: design of solutions to human problems; capacity of abstraction, analytical capacity and ability to synthesize.
2. Individual competences: a positive attitude to new situations and technologies, ability to work effectively.
3. Systematic competences: planning and organizational capacity, a preferential attitude to people with cognitive disabilities and/or limitations.
4. Common competences: analysis, design, construction and maintenance of applications capacities in a strong, safe and efficient way, with capacities

to choose the most suitable paradigm and programming language, and the ability to design and assess.

Furthermore, the guide establishes some learning results that the students should achieve by the end of the course, which are the following:

1. To analyze, design, build, adapt and/or test support technologies that would allow the users with some kind of disability to access the information technology.
2. To design and conduct research experiments to complete the scientific knowledge of the special needs from the user's interaction and from the cognitive models.
3. To build accessible and usable user interfaces from the requirements provided by the client and use the current legislation and regulations, which is applied to the development of user interfaces understanding, also, the importance of natural interaction and the integration of support technologies for users with requirements for special requirements.
4. To apply usability and accessibility evaluation techniques.

With regard to the 60 hours of the teaching work, there have been planned five types of work sessions to develop the teaching-learning process and achieve the competences and results suggested in the guide:

1. *Lectures and/or seminar sessions* – to acquire basic knowledge,
2. *Workshop Sessions* – to study cases or particular problems related to the studied matter or the studied unit, carried out individually or by organizing work group,
3. *Practical sessions* – carried out in computer rooms, where students would strengthen the acquired knowledge by a series of guided practice tasks that would require individual work or collaborative work in groups,
4. *Evaluation sessions* –assessment and review of the students' tasks and works carried out by the teachers and by their own classmates
5. *Tutorial sessions* – planned to give support to a student or a group of student's particular needs on the comprehension of the subject or performed task and a determined session in the planning for the whole class, generally to solve questions from the final project of the course.

To reach the established goals – competences and results – we have based out learning process on the model proposed by Bloom (1971). These sessions will be expanded on the following section.

Regarding the work hours for the students, the following sessions have been planned (Figure 1):

1. Self-learning sessions: carried out through readings and review of material related to the study subject and/or through the search for information, which is necessary know so it can be used in the planned activities at the practice and workshop sessions.
2. Self-assessment: there had been prepared a series of self-assessment tests, which are available at the end of every study unit.
3. Surveys – related to a specific study or to a particular study case: execution of tasks and development of small projects, that can be done individually or in groups.

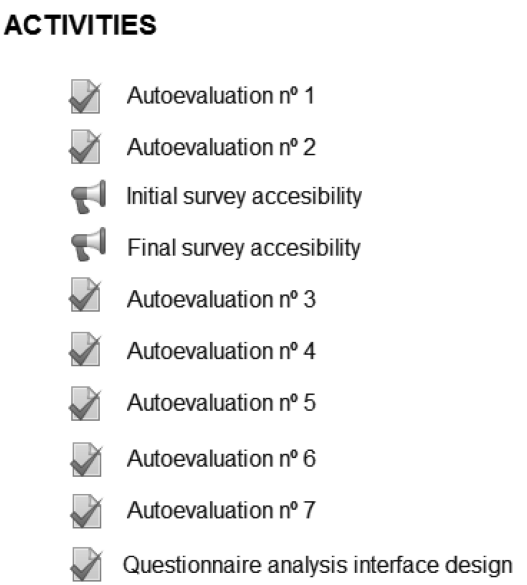

Fig. 1: Activities summary

The topics, through which the students are expected to gather knowledge and skills, are distributed in four main units:

1. *Augmented Reality and Accessibility fundamentals:* This section is focused on letting the students know about the tenets of cognitive theory and the different cognitive issues that could affect the use of an application – definitions, features, types – as well as their identification and negative consequences when experiencing an application. It is also focused on the study of guidelines and proposals to improve the design of interfaces for the different cases presented.

2. *Accessibility principles:* This section looks in the foundation of usability and accessibility on the design of interfaces – concepts, tenets, guides. We make a review of the existing national and international regulations and standards. These should be taken into account when designing an application. In addition, we also review the tenets of responsive design and natural interaction.
3. *Augmented Reality:* In this section, we study the basic knowledge, on which Augmented Reality is based – introduction, basic concepts, features, evolution, types, etc. – and the key principals of Augmented Reality – localization, recognition, monitoring, focus, context, points of interest, markers, etc. We also review the available technologies for the implementation of Augmented Reality applications such as mobile devices and Augmented Reality browser features, Toolkit, and languages that would allow us to introduce Augmented Reality solutions – e. g. Java, C++ and marker languages such as KML and ARML.
4. *Augmented Accessibility:* This section is focused on the study of the user's experience with Augmented Reality applications, their valuation and assessment; as well as, the research of recent studies on this matter, and the impact of natural interaction in this area.

In this way, we attempt to make the student reach the planned goals and the indicated competences on the previous section.

3. Teaching method

The course is planned to have teaching-learning sessions based on Krathwohl's (2002) proposals, who, after reviewing Bloom's taxonomy, established the learning levels in the following order: remember, understand, apply, analyze, evaluate and create.

Bloom's (1971) work is still valid in spite of the passing of time. He proposed a taxonomy of the learning goals, well defined in six major categories in the cognitive domain: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. As can be seen, Krathwohl's work not only changed the order of the levels but also renamed them. To that end, he used verbs instead of nouns, so that these desired goals would be better understood.

Although the model establishes the goals in the cognitive domain, we believe that is important to distinguish that the adopted model not only suggests to reach the cognitive goals – knowledge – but also strengthen and/or improve the affective – attitudes – and psychomotor – abilities to develop – aspects.

We take Krathwohl's (2002) proposal, adapting it to the course in particular, we take into account the digital tools available as a support for the model, and we considered them within the three established domains.

In the cognitive domain of knowledge, we focus on the learning goals, looking at providing information to the students, through direct teaching – lectures, texts, additional material – with the intention of making the students acquire the basic knowledge that would allow them to develop different tasks during the course. This domain should allow the students to be able to:

1. Remember, list and localize concepts, regulations, guides,
2. Understand, summarize and classify issues related to the UI, mobile devices and Augmented Reality applications that confront users in general, and especially those with cognitive problems. Analyze the most outstanding features or those with major impact in the proposed study cases or in the carried out projects,
3. Apply techniques or technologies; select those more appropriate to complete tasks or assigned projects,
4. Analyze, compare different solutions to the study cases, search and organize relevant and necessary information to propose solutions.
5. Judge, value and assess their own tasks and work or from other classmates in a critique and objective way. Carry out self-learning and value it through self-assessment with the digital resources available. Evaluate their proposed interfaces and applications by using tools in contrast to national and international regulations.
6. Develop the proposed tasks, plan and build small applications.

In the affective domain, the objectives are focused on strengthening the student's attention and active participation throughout the training process. In this domain, the student should be able to:

1. Come to an agreement with their fellow classmates in group activities,
2. Participate in debates and discussions to a suggested problem,
3. Participate, collaborate and share knowledge in group activities. This way, the students not only acquire basic knowledge, but also strengthen and/or improve their personal skills to carry out the tasks suggested to reach an effective work.

In the psychomotor domain, the goal is mostly focused on promoting and improving the verbal communication skills and oratorical abilities to explain their own ideas that were suggested during the group tasks; their progress throughout the performed tasks and projects; as well as, their ability to plan

and organize both the development of the suggested tasks and their presentation.

Figure 2 shows the summary of Krathwohl's (2002) improved model, adapted to our own needs and goals.

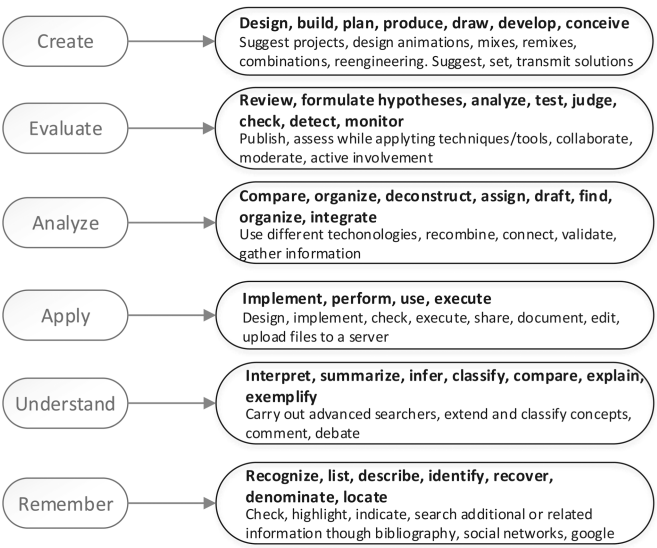

Fig. 2: Adaptation of Bloom model for the aims of the subject of ARA

The described learning model is put into practice throughout the different work sessions proposed for the course – that were mentioned in the previous section.

We will describe now in detail the first three types: lectures/seminars, practice and workshop sessions, leaving out the fourth one – evaluation – that will be further explained separately, because of its magnitude and importance in the evaluation of the expected learning results. The tutoring sessions are not included in this section because they were sufficiently described in the previous section.

1. Lectures and seminar sessions: We encourage the students to review the study material, and search for additional information through bibliography, by using not only both the provided material and links to material within the formal means of learning – University's own Moodle – but also through informal means of learning, and using the Internet as a support tool – through Goggle or other specialized search engines. In these sessions, the goal is to enhance the acquired knowledge and develop abilities in order to highlight and identify concepts and key ideas, and/or promote a debate about them.

2. The practice sessions – which take place in the computer room – are focused on the review and learning of the different guides, techniques and technologies available to perform the given tasks and develop the proposed projects. The goal is to obtain investigation, exploration and interaction skills in the students with the appropriate techniques and technologies. Through these activities, we would manage to make the students read, search, discuss, document and debate about the proposed experimental activities. These activities are organized as follows:
   a. Initial sessions dedicated to research, review and document the design tenets based on studies of cognitive problems, and valid usability guidelines, regulations and accessibility standards.
   b. Sessions dedicated to implement small projects based on the acquired knowledge from previous courses and the knowledge obtained from the research performed in previous sessions. The objective of these sessions is to identify the students' background on markup languages, such as HTML, Java and CSS3 sheets; and script languages, like JavaScript, in order to establish the feedback necessary for subsequent sessions.
   c. Review sessions of Augmented Reality technology based on localization and identification of markers. In these sessions, the student performs small tasks by using the available technologies.
   d. Development sessions of guided mini-projects using programming to implement them. By using both the acquired knowledge and the support material, the students should be able to perform mini-projects. The activities planned for these sessions will be carry out using Java for Android platforms, giving the students the liberty to work in the IDE they know best. Through these activities, we expect that the students would be able to implement, execute and share previously acquired knowledge about techniques/technologies and programming languages needed.

   In this regard, it should be noted that the course does not include the learning of programming languages, but it uses and strengthens the knowledge that the students already have at the beginning of this course. Therefore, the students are provided with some examples, so they would learn from those examples to deal with the given problems and suggest solutions.
   Furthermore, through these activities the students would become familiar with the assessment and evaluation of techniques and tools in the tasks and projects performed; and with the feedback received from the active participation from fellow coworkers and classmates in the assessment and evaluation of their work, that would allow them to make redesign decisions, that could also be reengineering decisions. These activities should be carried out

during the hours of personal research that the student dedicates to the course.

3. Through the workshop-seminar sessions done at the end of every unit, we present situations related to them in order to promote the critical analysis, to encourage the students to discuss and debate (individually or in groups) to reach a common opinion about the problems, study cases or the criteria, on which the students base the choice of some technique or technology, and suggest better alternatives or solutions.

   To ensure the highest level of learning, we present a series of controlled tasks to the students for their empirical study. In some cases, we give them the option to select topics of their own interest.

4. Evaluations

As the course is taught in the fourth year of the degree, the students are expected to have, apart from the required knowledge – knowledge of languages such as Java, JavaScript, HTML, CSS and tools like development contexts, editors, etc. – a certain level of maturity in order to successfully perform the development of the planned activities of the course. On these assumptions, we consider that, more than just doing a final exam, it is important to evaluate the acquired competences through the development of a series of tasks and work during the course, based on the imparted and assimilated knowledge through the different activities programmed for it.

The evaluation process applied to assess the students' competences centers them in the middle of the learning process (cf. Prince 2004) to reach not only the learning outcomes but also their active participation through a series of analytical, evaluation tasks and small-scale projects development. These tasks are carried out through:

1. *Analytical and evaluation activities:* through the different work sessions not only theoretical principles are provided, but the critic and independent thinking is also encouraged:
   a. In the analysis and discussion of the suggested problems or study cases and the proposal of solutions. The students should briefly summarize their proposal and explain it. Examples of this work are: investigation and analysis of support technologies for users with some kind of a concrete disability, investigation and/or determination of specific needs in the user's interfaces to cognitive problems, etc.
   b. Impartial and objective assessment of their fellow classmates' proposals to the performed tasks and projects – to achieve this, the student as-

sumes the role of user and bases his judgement on assumptions established by the teacher, not just as a mere observer.

The cognitive, affective and psychomotor domains are evaluated through these activities.

2. *Practical activities:* Within them, investigation, design, small applications development and/or expansion of some given are included. These activities are evaluated through individual and group tasks:
   a. *Individual practices*, the objective of these activities is to evaluate the acquired competences individually through the resolution of cases and extension of small-size projects.

      For instance, the students receive an application and they will be asked to make some changes/adjustments needed to adjust them to a particular audience, to improve the accessibility and usability, or reach a more natural interaction. They could be also asked to evaluate the accessibility/usability of a given application using different tools suggested by the professor or other suggestions made by him and based on the results, the student would propose changes and upgrades.
   b. *Group practices*, this activities evaluate the student's ability to work in groups – involvement, collaboration and communication (cf. Sánchez 2014) – in the development of Augmented Reality projects specially intended to people with cognitive problems and with some disability. To this end, the class will be divided in small groups – of 2 or 3 students – and they will be asked to suggest a solution, which they should reach in the group together in consensus; after that, one of the members is selected by draw to make a presentation of that solution to the rest of the class. They should explain to their fellow classmates what they did, which problem they would solve, whom is that solution for and which problems did they have.

   At both analytical and evaluation activities and at the practical activities, the students' proposals to a problem or study case are analyzed and evaluated by their classmates. These activities allow the student not only to think, analyze and evaluate other proposals, but also help them to focus on ideas and knowledge, and at best, to consider reengineering their own works when analyzed by their classmates. This allows them to be aware of their mistakes and their classmates' misunderstandings resulted from their explanation. Listening to other students correct them would also contribute to a better comprehension. Furthermore, in order to get the attention of the rest of the class, a random classmate would be asked to sum up what they understood of some particular aspect of the presentation and their own point of view – either if they agree or disagree and why). Each student or group –

depending on the case – would assess the presentation and the solution suggested using a scale of five points.

3. *Submission of papers:* The goal of these activities is to assess the students' investigation, analysis and written communication competences and skills, the resolution of crossed questions – between students, between teacher and students – and production of documents related to the tasks and projects (cf. Amengual/Marqués 2013, Marqués *et al.* 2013) that must be defended and debated. These activities will help the students in their own assessment and correction of their work, providing knowledge and ideas while improving the learning process. These are not long documents; and in some cases, they must be presented in a particular format, because they pursue the student to apply their synthesis skills to present the most important ideas.

5. Conclusions

Augmented Reality has grown and evolved by the hand of the new technologies. This matter challenges both teachers and students to look at the development of applications from a new perspective.

This challenges teachers to adapt the contents of the course to the study programs to emphasize the long-lasting structural contents, and it also challenges students to develop applications mainly for mobile platforms – smartphones, tablets, etc. – taking into account that they should reach applications that would offer better access to information than what reality may show and that people with cognitive disabilities and limitations must be included in the development process.

Furthermore, the success of the teaching-learning process of the course depends on the transversal coordination of the contents of previous and/or parallel courses that guarantee the required competences to achieve the expected goals.

Finally, the applied method guarantees a high amount of participation from the students at both an individual level and as a group, preparing them not only to defend their individual and group ideas and suggestions but also to carry those ideas out successfully, and also to train them for debates and discussions that could come up in their presentation, so they would be able to satisfy their audience, who will assess them.

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