N° d'ordre : 142 Année : 2015 / 2016

جامعة عبد المالك السعدي
Université Abdelmalek Essaadi

UNIVERSITE ABDELMALEK ESSAADI
FACULTE DES SCIENCES et TECHNIQUES
TANGER

Centre d'Etudes Doctorales : « Sciences et Techniques de l'Ingénieur »
Formation Doctorale : « Sciences et Techniques de l'Ingénieur »

THESE DE DOCTORAT

Présentée

Pour l'obtention du

DOCTORAT EN SCIENCES ET TECHNIQUES DE L'INGENIEUR

Par :

EL AACHAK LOTFI

Discipline : Réseaux, Informatique et Télécommunication

Spécialité : Informatique

Titre de la Thèse : Etude des jeux vidéo 3D pour le web et leurs applications dans le E-Learning.

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Structure de recherche accréditée d'accueil :
Laboratoire d'Informatique et Systèmes de Télécommunication de la FST de Tanger (UAE/L08)

Study of 3D video games on the web and their application in the e-learning

by

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Submitted to the Department of Computer Science
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy of Science in Computer Science and Engineering

at the

Faculty of Sciences and Techniques of Tangier

Spetembre 2015

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Study of 3D video games on the web and their application in the e-learning

Abstract

Learning through video games "Serious games" is a new trend in the distance learning area, including e-learning systems; it has opened several opportunities for the instructors and pedagogues to change their manner of teaching, in order, to increase the desire and envy into the player/learner to play and learn new skills at the same time. This revolution has changed the mission of the video games from a simple tool dedicated to entertaining, into an effective tool used in education. Since the appearance of serious games several 3D and 2D video games have been developed in order to solve specific issues related to the learning, and training in some fields e.g. "education, industry, health care, etc". Many research works have been done by several institutions and universities concerning the game design methodologies, the application fields of serious games, the game engines, the serious games assessment systems, and the learning analysis through serious games. All of these research works in serious games can offer several possibilities for the researchers to innovate and bring new ideas for the purpose of the enfranchisement and the progression of the education.

In fact, this thesis discusses several works done by our research team concerning some research axis in the serious games area, we have adapted a design methodology "Rapid prototyping model" often used in instructional design into a design methodology for serious games. This methodology will be dedicated to the non-experts. Several serious games have been developed by the students and through the proposed methodology to verify the efficiency of the proposed methodology. We have also developed a web-based serious game generator for the instructors that allows them to generate their own video games, in order to solve specific issues related to education. Then we have cantered our efforts to establish a new system based on multi-agents system, the main objective of this system is to guide and assist learners during a sequence of video games and also collect information about them, then the data will be analyzed by the educational data mining algorithms and learning analysis algorithms in order to offer to the instructor a global view concerning both performances and learning progression of the learners. As a final part, we have developed some serious games in some areas, e.g. "religion, health care, Arabic sign language, etc.".

To reach the objectives considered for each work, we have followed a working methodology based on several studies concerning other research works made by researchers in the field; according to these researches we have developed new ideas. Briefly, this thesis contributes on the one hand to help instructors to change and improve their teaching methods, by offering to them tools and utilities to do this in an easy way, on the other hand to help players/learners to improve their learning level and to acquire new skills in a both interactive and attractive way.

Résumé

Apprendre á travers les jeux sérieux, est une nouvelle tendance qui a apparu ces dernières années dans le domaine d'apprentissage á distance. Cet outil d'apprentissage a permis aux instructeurs et aux pédagogues de remplacer leurs méthodes classiques par des méthodes plus interactives. L'objectif principal de ce changement était d'attirer l'attention de l'apprenant et de créer l'envie et le désir chez lui pour acquérir des nouvelles connaissances et compétences en jouant. Ce qui a changé la mission du jeu vidéo d'un simple outil de divertissement vers un outil pédagogique. Pour cette raison, plusieurs jeux sérieux "2D, 3D " ont été développés dans l'objectif de résoudre des problèmes spécifiques pour certains domaines, "éducation, industrie, médecine, etc. ". Ainsi plusieurs travaux de recherche ont été élaborés par différents laboratoires et universités concernant plusieurs axes : la conception des jeux sérieux, les moteurs des jeux sérieux, la performance des joueurs, l'analyse d'apprentissage dans un jeu, ainsi les différentes applications des jeux sérieux dans des domaines spécifiques.

Cette thèse traite plusieurs projets réalisés par notre équipe de recherche concernant certains axes du domaine des jeux sérieux. Nous avons adapté en premier lieu une méthode de conception fondée sur le modèle de prototypage rapide souvent utilisé dans la conception pédagogique, pour être en mesure de modéliser un jeu sérieux. Nous avons également développé un générateur de jeux sérieux pour le web. Ce générateur va permettre aux instructeurs la création de différents jeux vidéo qui sont á la fois éducatifs et ludiques. Le processus de génération est fondé sur des mécanismes et outils simples "éditeur de scénario, éditeur des niveaux de jeux, etc. ". Le générateur proposé dispose aussi d'un système de décision multicritères qui va aider l'instructeur á choisir le genre du jeu qui lui convient le plus, selon les critères "âge, domaine, propriétés de jeu". Il dispose aussi d'un système expert flou qui va guider l'instructeur durant le processus de la génération. Ensuite, nous avons établi un nouveau système fondé sur le système multi-agents, dont l'objectif de guider et d'aider les apprenants au cours d'une séquence du jeu vidéo. Ce système va permettre la collection des données de chaque apprenant. Ces données seront par la suite analysées par une combinaison d'algorithmes de datamining et d'analyse de l'apprentissage, afin d'offrir aux instructeurs une vision globale sur la performance et la progression des apprenants. Nous avons ainsi développé durant la thèse plusieurs jeux sérieux dans certains domaines : Religion, Médecine, langage des signes, etc.

Pour atteindre les objectifs envisagés á chaque contribution de cette thèse, nous avons suivi une méthode de travail qui consiste á se focaliser sur plusieurs études bibliographiques et travaux de recherche réalisés par différents chercheurs dans le domaine des jeux sérieux. Selon ces recherches, nous avons pu développer et améliorer de nouvelles idées et solutions á des problématiques bien spécifiques. En bref, cette thèse contribue d'une part á aider les instructeurs á changer et améliorer leurs méthodes d'enseignement, en leurs offrants des outils et des utilitaires faciles pour la création des jeux sérieux. D'autre part aider les apprenants á améliorer leurs niveaux d'apprentissage et acquérir des nouvelles compétences d'une manière interactive.

Remerciements

A Allah

A mon Directeur de Thèse Porfesseur **Bouhorma Mohamed**

pour m'avoir fait l'honneur de diriger ma thèse. Son soutien, ses directives et instructions m'ont permis de m'armer, de se renforcer et de poursuivre toujours mes travaux avec succés. Je tiens également à souligner que la confiance qu'il a mise en moi a été un moteur á ma réussite.

Je remercie profondément tous les membres de jury

- 1 Pr. FENNAN ABDELHADI
- 2 Pr. EL AMRANI CHAKER
- 3 Pr. LYHYAOUI ABDELOUAHID
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A ceux que personne ne peut compenser les sacrifices qu'ils ont Consentis pour mon éducation et mon bien être les deux grands héros de ma vie mon père et ma mère

A ma femme Souhaila Menaoui, pour sa patience et son soutien qu'elle n'a cessé d'apporter au cours de mon doctorat

A toute ma famille, A mes amis et A mes collègues, surtout Mr Amine Belahbibe.

Je remercie Mr moustapha el Hachmi

Vous qui m'admirez tant, soyez sûres que ce travail est le résultat de votre confiance en moi, Que dieu vous garde.

Tanger, le 01 Février 2016.

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Chapter 1

Introduction

1.1 General introduction

Nowadays the application of 3D video games has exceeded the traditional use in the entertainment area to other areas such as education, this kind of video games is known as “serious games”. The employment of serious games in the education field is due on the one hand to the technological progress that the field has known, with the integration of several information technologies, and the inclusion of several new tools, e.g. “data-show, e-learning, serious games, etc.” in the teaching process, these tools have proved to have an important impact on the learners thanks to their advantages, on the other hand, the features of video games more especially 3D serious games, allow the learners to live both more beneficial and entertaining experiences.

The year 1970 has known the first application of serious games in the training field [1], the U.S. research laboratory has created a game used by officers to study the Cold War conflict on a worldwide scale, since this date several other serious games have been developed according to the needs that keep to increasing and thanks to their relevant results, their positive potential, and their ability to tackle a specific problem or to teach a certain skill. As known, the activities involving video games will increase student motivation and will help them to improve their cognitive abilities and allow them to build new skills. Many institutions, laboratories, and pedagogues are developing serious games for learning [2].

However, until today, it has been difficult to develop such video games, and it's difficult also to claim that this really meets the learner's requirements, due to unclear standards and guidelines used to design such video games, therefore, it's necessary to have a design methodology with clear phases, based on an iterative process, dedicated for the beginners and the non-experts in game design. The main objective of this methodology is to enable the beginners to develop serious games, and to introduce to them the concept of the serious game design. In most cases the instructors are the first actors that begin the process of serious games development, therefore, their role is primordial, because they establish the pedagogical objectives that will be transmitted to the learners through the serious games, So there must be a tool that will allow the instructors to generate their own video games based on their pedagogical objectives, without interaction of the game designer, the development team nor the artistic team. With this approach the instructors that are non-experts in the game creation field will be able to create their own serious games easily, which will allow the acceleration of the creation process, the gain of time, and the decrease of the realization cost. For those reasons, we propose in the first place the adaptation of a design methodology often used in the instructional design, to be able to design serious games, then we propose a new web-based serious game generator for the non-experts e.g. "experts, instructors, pedagogues , etc.".

The efficiency of serious games depends on the features, the quality of the knowledge transmitted to the players/learners, and the player performances that reflect the learning level of the player. Among the features of serious games there are: interactive environment by using several input devices, several techniques that attract the attention of the learner like goods story, challenges, system of rewards, all of the features cited above will attract players and create mood in them to play more. Concerning the quality of the knowledge transmitted to the learners, it will be guaranteed through the use of the non player-characters, sound, or animations. The efficiency can be measured and analyzed by collecting data of each player, therefore the measurement of player performances, and then the collected data will be analyzed. Thereafter used by the instructors, the main objective of this analysis is to give instructors a global

view on the progression of their students, the detection of problems and gaps to improve the teaching manners. The player performances analysis and learning analytics represent an important area of researches. We propose a multi-agents system that guides the learners during the sequence of the game, and analyzes their performances based on both educational data mining and learning analytics algorithms.

The serious games can cover a wide variety of fields, e.g. "education, health care, religion, industry, etc."; several applications have been developed according to both specific need and situations. The use of those applications with input devices, e.g. leap motion, kinect, etc., can be used to train, educate, and improve the knowledge level, as if in learners where leaving them in real situations, with added advantages. We have developed both 2d and 3d serious games during this research thesis, in several areas, e.g. "religion, health care, environment, etc".

1.2 Problematic and objectives of research

1.2.1 Problematic of research

The work in the study of serious games imposes confrontation to several challenges, and problems related to the complexity of the design and development processes of this kind of video games, with the lack of universal standards with easy and clear steps, the lack of graphical resources, e.g. "2D objects, 3D objects", the complexity related to the adaptation of the existing code source that will be reused in other realizations, the difficulties related to the measurement and analysis of the knowledge level and the performances of each learner, in order to make decisions concerning the improvement of the teaching methods, the challenges related to the application of serious games in e-learning systems to resolve the specific issues, and to learn new skills for the learners/players.

The game creation process of serious games requires the interaction of several actors, e.g. "game designers, artistic team, development team, pedagogues and experts in the fields, etc.", each actor has a specific role during the process, which requires cooperation between those actors, and an exchange of documents among them for a good progression of the full project. In most cases the design methodology adopted by several companies and institutions requires a lot of time, resources and an important cost of realization; in addition, they are not adapted for the non-experts in the video game creation field like students and people who want to learn the game design. The first research question is as follows:

RQ1: How to develop both 2D and 3D serious games in laboratories, universities, and small companies, knowing that the creation process is complex one and requires a lot of resources, time, and cost of realization.

After the adaptation and utilization of a design methodology for the non-experts in order to develop their own serious games, another issue appears on the one hand the complexity related to the adaptation and utilization the existing code source, in order to save the realization time, the lack of graphical resources due to lack of computer graphics experts able to create 2D and 3D objects. On the other hand the instructors

and pedagogues play an important role to make a serious game with a cognitive value; unfortunately, in most cases the instructors find it difficult to express their needs to the game designers; also, the game designers find also several difficulties to introduce the pedagogical objectives in serious games. The second research question is as follows:

RQ2: What is the tool that can be used by the instructors, and that allows them to create their own serious games without the intervention of game designer, the development team or the artistic team ?

During the development of the tool capable of generating several web-based serious games dedicated for the non-experts, another problem has appeared, it consists of how to choose the most adapted game genre according to the criteria, e.g. "age, field, game properties, etc." given by the instructor, because there are several game genres, e.g. "Platformer, Adventure, RTS, RPG, etc.", and the instructor can't choose the game genre that corresponds to his need, now that he is non-expert in video games filed. The third research question is as follows:

RQ3: How to select the most adapted game genre according to the criteria given by the instructor ?

The success key of any serious game, is its ability to transfer the knowledge to the learners in a amusing and interactive way. The efficiency of the knowledge transfer and the learning of new skills through serious games, depends on several factors among those factors there are the clarity of the messages transmitted to the learners, the methods followed to attract the attention of the learners, the systems that help learners during their progression in the video games. The efficiency of the serious games is related to the performances of each player and it's related also to the quantity and quality of information acquired by the learner during the game sequence. The fourth research question is as the follows:

RQ4: Which are the mechanisms that can be integrated into serious games, in order to improve the learning capacities of the learners, and at the same time allow the instructors to analyze the performances of their learners ?

Several learning issues have been resolved through the use of serious games, thanks

to the features that they offer; the application of this kind of video games can be integrated in several e-learning systems, the main objective of this integration is to offer a full learning system with a large variety of choices. The fifth research question is as the follows:

RQ5: How to resolve a specific issue through the serious game and apply it in an e-learning system ?

1.2.2 Research objectives

This research thesis focuses on several areas concerning serious games and their application, According to the research issues described in the section above, we have focused our present work on the introduction of a new design methodology for 2D and 3D serious games, the establishment of a web-based serious game generator for the non-experts, the establishment also of a system for guidance and player performances analysis, and some implementation of serious games in some fields. To reach our objectives, we plan to:

- Study a variety of instructional design methodologies and game design methodologies, in order to create or adapt a new serious game design methodology that will be used by the non-expert and the beginners; the main objectives of this methodology are to introduce game design basics to the students thanks to its clear step by step and iterative process, and allow the reduction of time and cost of its realization.

- Establish a web-based serious game generator, dedicated for the instructors and the pedagogues, to create their own serious games, the proposed game generator allows the creation of 2D and 3D video games according to the chosen game genre, e.g. “Platformer, Puzzle, Adventure, RTS, RPG, etc”. It also plays a role of expert because it gives indications to the instructors during the game generation process, in order to create a video game that is both educational and amusing. With this game generator the instructors will need neither a

game designer nor a development team, and will focus more on the educational objectives that will be transmitted through the generated game.

- Establish a system of guidance and player performance analysis, this system will be integrated in a serious game, the objectives of the proposed system are: the guidance of the players during a sequence of the game in order, not only to improve their performances, and also to accelerate the process of learning. Another objective is allowing the instructors to have a global view concerning the performances of their students that play the game, in addition to a detailed analysis concerning their learning outcome.

- Develop some "2D and 3D" serious games that resolve specific issues, in several areas like Arabic language teaching, religion, environment, health care, the development of some serious games has been done by using the design methodology mentioned in the first objective, in addition to the evaluation of those realizations according to the feedbacks of the learners and the integration of those developed games in e-learning systems.

1.3 Thesis structure

Besides the introductory chapter that lists a research issue observed in the serious game field, this thesis is organized into the following chapters:

The second chapter provides a state of the art concerning the e-learning systems, serious games, several design methodologies, and application of serious games in different areas, those topics are among the main axes of this thesis. Therefore, the literature is so rich. Although this literature deals with more topics of serious games, but also lists the famous challenges which attract more researchers.

The third chapter presents the realized works. The architecture of this chapter adopts an American model organizing it in sections. Each section lists some detail of a research paper. The five sections give details of the results of published work in game design methodology, game generator, system of guidance, learning analytic based on multi-agent system, a serious game that teaches Arabic sign language and its integration in e-learning system.

The final chapter contains a general conclusion about the work presented in this research thesis, with a description of the perspectives concerning the future research works.

1.4 Working methodology

The working methodology chronologically describes the research methodology we have adopted to best meet our objectives. To do this, we started by looking for more references and documentation in order to clarify and identify the best methods that lead to solving the problem related to our line of research. A study on surveys of serious games design methodologies, game engines, player performance analysis, and serious game application, allowed us to formulate the main issues. The participation in several national and international conferences has also helped us to know more related changes and news of our topic.

We have fixed at the beginning the main objectives of the thesis, but during the progressing work on the thesis, we have encountered several problems, those encountered problems have changed both our method of thinking and some objectives fixed at the beginning, then we have tried to solve them. This methodology of working has allowed us to experiment several solutions in order to choose the best one. As an example, during the work on the methodology already used in instructional design to be adapted for the serious game design, we have noticed the need to develop a game generator dedicated to the instructors. The same thing during the development of the game generator we have noticed the need to develop a system capable of selecting the kind of game most suited to a set of parameters sent by the user. During the progression of the thesis and the encounter of issues that need to be resolved, all of this should be done with the respect of the objectives already mentioned.

Before turning in this report, several papers have been submitted and validated by scientific committees and have been published in many international journals. The next part gives a list of the publication published in international journals or international conferences and workshops.

1.5 Personal publications and communications

1.5.1 Publications in internationals journals

1. El Aachak Lotfi, Belahbib Amine, BOUHORMA Mohammed, Adaptation of Rapid Prototyping Model for Serious Games Development, Computer Science, Information Technology, Vol 2 No 2 June 2014, DOI>10.15640/jcsit.

2. Lotfi Elaachak; Amine Belahbib; Mohammed Bouhorma, Application of Analytic Hierarchical Process Method for Video Game Genre Selection, International Journal of Computer Applications, vol. 96, issue 16, pp. 30-37, DOI>10.5120/16881-6888

3. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Players Performances Analysis based on Educational Data Mining Case of Study: Interactive Waste Sorting Serious Game International Journal of Computer Applications ©2014 by IJCA Journal, Volume 108 - Number 1, Year of Publication: 2014, DOI>10.5120/18954-0217.

4. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Towards a System of Guidance, Assistance and Learning Analytics Based on Multi Agent System Applied on Serious Games, International Journal of Electrical and Computer Engineering (IJECE) 5.2 (2015): 344-354.

5. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Teaching Arabic Sign Language through an Interactive Web based Serious Game International Journal of Computer Applications 2015 by IJCA, Volume 116 - Number 3, Year of Publication: 2015, Doi >10.5120/20315-2372.

6. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed,TOWARDS A NEW WEB-BASED SERIOUS GAMES GENERATOR BASED ON FUZZY EXPERT SYSTEM, Journal of Theoretical and Applied Information Technology, June 2015 — Vol. 76 No.1.

1.5.2 Communications in conferences

1. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Approach to teaching immunological technique by serious game, The First International Conference in Nursing and Health Science, Convention Center, KSAU-HS University, Jeddah, Feb 2014.

2. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, A Digital Revolution In Nursing Education-The Serious Games, The First, International Conference in Nursing and Health Science, Convention Center, KSAU-HS University, Jeddah, Feb 2014.

3. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Learning to Pray, Islamic Children's Game, The 4th International Conference on Multimedia Computing and Systems, Marrakesh, Morocco, April 2014.

4. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Serious Games in Business Field, the Challenges and the Perspectives,Les Journes d'Intelligence conomique - BIG DATA MINING, Tangier Mrocco, May 2014.

5. ELAACHAK Lotfi, BELAHBIBE Amine, BOUHORMA Mohammed, Towards a New Concept of Serious Games Generator, International Conference on Electrical and Information Technologies ICEIT'15, March, 2015 Marrakech, Morocco.

1.6 Conclusion

The serious games field is both new and a huge topic of research which can offer several opportunities to find a lot of ideas and new challenges. We are interested in the topics that presented for us major challenges about the learning through serious games. During this chapter we have introduced the thesis by giving the issues related to the design, creation, learning analytics, and application of serious games, then we have presented a list of publications related to each problem encountered during the progression of research works, in addition to the methodology adopted to reach the main objectives.

The next chapter contains five sections introducing a survey on different topics as:

- e-learning systems,
- Serious games,
- Game design,
- Game engines, etc.

Chapter 2

General Survey

2.1 Introduction to E-Learning : A Survey

2.1.1 Definition of E-Learning

There are a variety of definitions and labels for e-learning like education through website, electronic training, etc. Each definition is part of a trend; some are focused on technological support, other on distance. Some insist on the pedagogical aspects, the method of tutoring or the type of interaction between actors, while others offer a synthesis. The most popular definition of the e-learning is: the e-learning is a distance education based on modern technologies of communication, including the computer technologies and software like Computer and Network technologies, search engines, electronic libraries, and web based applications, archived in universities, schools or through web based applications.

This kind of learning is delivered through the medium of the World Wide Web (abbreviated as WWW or W3) where the educational institutions and universities make their programs and materials available on special web applications in such a manner that learners are able to make use of them and interact with them with ease through closed or shared, Intranet, Internet, and through the use of e-mail, forums. On the other side, the definition of e-learning centres on it's been the learning methods and techniques for the presentation of academic programs via the Internet or any

other electronic media inclusive of multimedia e.g. “computers, mobiles or other new education technologies”.

According to Keegan in [3], the definition of e-learning is a form of education characterized by:

- The separation of teacher and learner throughout the length of the learning process.
- The influence of a learning and educational organization in the planning and also in the preparation of learning materials and in the provision of student support services.
- The use of audio, video or computer, to unite instructor and learner and carry the content of the course.
- The provision of bidirectional communication so that the learner may benefit from or even initiate dialogue.
- The absence of the learning group throughout the length of the learning process, with the possibility of occasional meetings, either face to face or by electronic tools, for both didactic and socialization purposes.

In the 2000s, Kaplan-Leiserson, in [4], has developed an e-learning system, which provides this definition: E-learning covers a wide set of applications and processes, such as Web-based learning environment, mobile-based learning, virtual schools, and digital collaboration. It includes the delivery of educational content via Internet, intranet/extranet, videotape, satellite broadcast, interactive TV, input devices and CD-ROM. E-Learning assists in the transformation of the educational process from the stage of learning by rote to one characterized by creativity, interaction, attractiveness and the development of skills. The student, in e-learning, is able to access educational materials at any time and from any place, thereby transforming the concepts of the educational process and learning to go beyond the limits imposed by traditional classrooms into a rich environment in which there are numerous sources of learning.

Dichantz, in [5], defines the E-learning as the collection of teaching and information packages in further education which is available at any time, any place and are delivered to learners through electronic devices. They contain blocks and units of information, tests and self-testing batteries, which allow a rapid self-evaluation for quick placement. E-learning system offers lower level learning objectives. Higher order objectives like understanding, reasoning and judging are more difficult to achieve. They require an individualized interactive discourse and can hardly be planned.

As we notice that there are many definitions of e-learning, these definitions have been changed during the years, and according to the technological progress that multimedia tools and mediums have known. With this progress, the definition of e-learning will be changed with the emergence of the new multimedia technologies and their integration in the learning process in the future.

2.1.2 The benefits of E-Learning

The benefits of e-learning can cover several actors and sectors e.g. "Education, Learners, Instructors, etc.", several studies and papers have been done to discuss the benefit of the e-learning in different application areas, according to the paper of Vikrant et al [6], the role of e-learning in education will grow substantially in the future. The drivers are partly economic, but growth is also driven by the rising demand from learners, who increasingly use technology in each day and who want more flexible forms of study and learning programs better tailored to their needs. The benefits of e-learning are well documented and accepted. These benefits are not only for the Education field, but also for the other fields e.g. "industry, healthcare, business, religion, etc.".

Benefits for education

Among the benefit of E-learning system on education there we find:

- Improve the quality of the learning experience.

- Help to remove barriers to achievement, by providing new ways of motivating and engaging learners of all abilities, and attaining their educational potential.
- E-learning can support learning by offering distinguished learning, particularly for the learners who need support in several areas.
- E-learning offers a diversity of tools to enable instructors and learners to be innovative, creative and resourceful in all learning activities.
- E-learning creates on-line communities of practice. The Internet can bring learners, instructors, expert communities, and other interesting people, to share ideas and good practice in the field.

Benefits for learners

Among the benefit of E-learning for learners there are:

- E-learning can provide a personalized learning experience for all learners.
- E-learning can facilitate fairer access to further and higher education by giving several possibilities for the learners according to their needs.
- E-learning provides personalized learning support via information, advice, and guidance services. It can help learners find the course that matches their need.
- E-learning provides virtual learning environment where learners can take part in creative learning with others through simulations, role-play, remote control of devices, on-line courses, etc.

In addition, the E-learning answers the requirements of the several development plans aimed at qualified human resources especially the employees as well as increasing the opportunities available for continuing education, training and professional development for those already working in different fields. Moreover, e-learning makes it possible for children, teenagers and adults, including the housewives to invest their free time in educating themselves and gaining the skills and experience that they desire.

Improving performance through learning

Studies by Towards Maturity [7] indicated that 69 % of report participants have improved their effectiveness of learning using on-line web-based applications. Among study cited by Welsh, in [8], includes a meta-analysis of literature on learning effectiveness, found that the learners learn more using computer-based instruction than they do via the traditional methods. Such as the case in military training, learning outcomes were either better or equal to those from e-learning courses, compared with their classroom. Studies from the field of education show that e-learning learners tend to do better than traditional learners [9].

In the year of 2010 the US Department of Education, in [10], has motioned the evaluation of evidence-based practices in on-line learning. In its report a meta-analysis and review of on-line learning studies concluded that both on-line and blended solutions produce better learning results than traditional methods of instruction. Learners who took all or part of their class on-line performed better, on average, than those taking the same course through traditional face-to-face instruction. Learning outcomes for students who engaged in on-line learning exceeded those of students receiving face-to-face instruction.

Economic Benefits of e-learning

According to Intel study [11] a lot of examples indicate that eLearning investments can improve economic development in two ways: by direct job creation as governments procure the PCs, networks, software, and services to support the eLearning deployment; and indirectly, by developing a better educated workforce.

David Leaser, in [14], has mentioned in his paper that the worldwide corporate e-learning market reached $17.2 billion in 2008. IDC forecasts that it will grow at a CAGR of 8.0% to approximately $25.4 billion by 2013. Content (rather than systems or delivery) represent the largest segment of the e-learning market, accounting for well over half of total spent.

According to Brandon Hall, in [12], there is very strong evidence that e-learning

reduces the total cost of training when compared to instructor led training. There are many case studies of cost savings being achieved through the use of e-learning, below there are some examples from Epic [13]:

- In 2010, British Airways announced that their award winning "Aviation Medicine" e-learning program, would reduce training costs by 1.1m over 3 years.
- Protecting Information, another e-learning program developed by Epic on behalf of the Cabinet Office, had generated an estimated 20m cost savings across government in 2010.
- The use of e-learning had generated over 1m of cost savings in the first year. They indicated that they had reduced training costs by nearly 50% by switching to e-learning.
- In a 2011 study, Towards Maturity indicated that on average, organizations were reporting cost savings of 26% through the use of e-learning.
- In 2008, BT announced the Dare2Share e-learning project would, at a conservative estimate, deliver total efficiency savings of more than 8m a year in employee time as well as in travel costs.

According to David Leaser, in [14], IBM estimates that as much as 40% of public classroom training costs are spent on travel and lodging. To determine the real cost of classroom training versus an e-learning solution, you should consider the following costs:

- Tuition
- Employee travel
- Lodging
- Vendor costs
- Instructor expenses

- Administration
- Real estate / room rentals

In addition, the lost opportunity is a real cost. For example, if an employee must spend eight hours travelling to a training class, the employee salary is just one expense: sales and business losses from downtime should also be evaluated.

David Leaser, in [14], has mentioned in his paper that the Improvements in employee productivity can provide a measurable return for a training solution. An IBM training assessment and implementation at an energy company with 1,000 employees found that companies can save significantly on labor costs with minimal investments in employee skills development. The study concluded that training which produced an average productivity improvement of only three minutes per day would save the company at least US $240,000 per year.

- Annual average employee salary is US $40,000, or US $20/hr.
- Employees worked 50 weeks per year.
- 1,000 workers saved three minutes per day, or one hour per month.

According to different studies already mentioned above, we can conclude that the impact of e-learning is more important in all training areas, the e-learning can play a paramount role in the future of educational programs and also for training in companies, thanks to the economic and organizational benefits that it offers and in addition it can influence automatically the skills of employees to increase the performance and production.

2.1.3 Instructional design and standards of e-Learning

International organizations, software houses and universities develop standards that cover all aspects of e-learning. However, such standards usually fit to the needs of specific applications and are inadequate for supporting the interoperability of e-learning [15].

The development of proprietary tools that use custom standards and protocols should be discouraged since it generates confusion and decelerates the growth of e-learning communities, as it was the case with multimedia technologies. Iraklis Varlamis et al, in [16], has mentioned in their paper that the pioneers of the e-learning community cooperated in order to define standards, protocols and architectures for the development of e-learning content, services and products. International consortia comprising standardization organizations, institutes and software houses undertake the coordination of players in the e-learning market chain. They collect user requirements, issue specifications for e-learning systems, develop and test applications, which validate the user requirements and convert the approved specifications into standards.

Instructional design gives purpose and shape to all forms of structured learning [17], and so encompasses formal e-learning. E-learning and instructional design is inescapably intertwined. Several instructional designs have been adapted for e-learning these recent years to meet the need gradually increasing by the learners, a lot of universities, companies and researchers have proposed or adapted their own instructional design for E-Learning, which gives a variety of choices to the e-learning designer to choose their suitable methodology.

In this section we will present a state of the art bout the most used methodologies to design an E-learning system. In this part we will present some popular models, methodologies and process often used both in instructional design and e-learning with an overview on the characteristics and properties related to each methodology and process.

ADDIE Model for e-learning

The most popular methodology to design e-learning is called ADDIE model developed by the Florida State University [18], which is diagrammed Figure 2-1. The process involved in the formulation of an instructional systems development (ISD) program for military inter-service training that will train individuals to do a particular job. The ADDIE model includes five stages: Analysis, Design, Development, Implementation and Evaluation.

Figure 2-1: The ADDIE model for e-learning.

ADDIE is often criticized as being too systematic; however, it is a useful starting point because instructional design looks at the 'big picture'. It also provides a rough representation of good practice. ADDIE and its variants may seem behaviourist at first glance; however, they don't actually prescribe a particular educational methodology. Instructional design based on behaviourism, constructivism, and social-constructivism are all possible using the ADDIE model.

Dick and Carey Model for e-learning

The Dick and Carey (DC) model is based on a systems approach for designing instruction. One of the best known models, and perhaps, the most popular and widely used ID models in use today, is in its sixth edition [19]. It has been the leading behavioural instructional systems design model [20, 21] since its first release to the public in 1968; later, the model was published in 1978 by Walter Dick and Lou Carey in their book entitled 'The Systematic Design of Instruction'. Its most recent version describes all the phases of an iterative process that starts by identifying instructional goals and ends with summative evaluation. It consists of the following ten components that are executed iteratively and in parallel rather than linearly:

Assess needs to identify instructional goals :

- Conduct instructional analysis
- Analyze learners and contexts
- Write performance objectives
- Develop assessment instruments

- Develop instructional strategies and select instructional materials
- Design and conduct formative evaluation of instruction

One particularly significant alternative is that of Dick and Carey in Figure 2-2. This particular model starts with instructional goals and progresses through to evaluation. It also includes a clear feedback and revision loop.

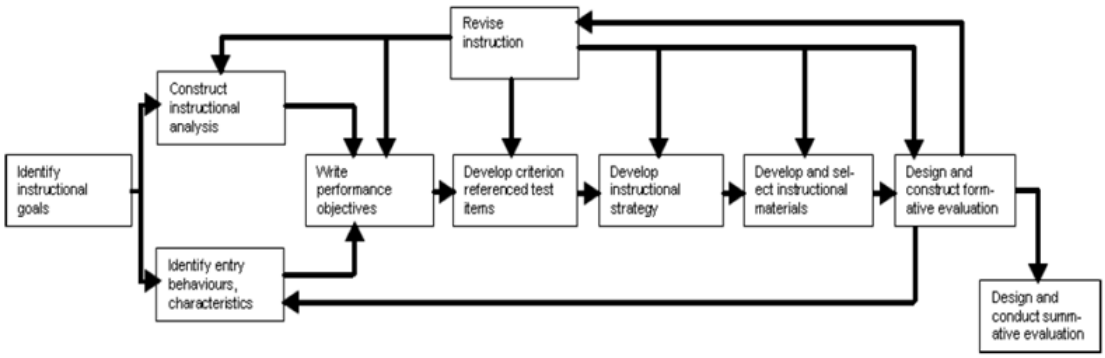

Figure 2-2: The Dick and Carey model.

Rapid prototyping Model for e-learning

The Rapid prototyping model is a design approach adapted both to instructional design and E-learning fields from the discipline of software engineering by Tripp and Bichelmeyer, in [22]. According to them, as with software engineering, rapid prototyping in instructional design is the building of a model of the system to design and develop the system itself. It focuses on continual or formative feedback which has some relevance on assertion that the activities of the instructional designer need to take place at the time the student is working with the instructional material. He maintains that instructional design decisions should be made on the fly as a response to student involvement in the learning process. This design approach has sometimes been cited as a way to improve the generic ADDIE model. It comprises a set of concurrent, overlapping four-level parallel process that will help both to speed up the process and to overcome many limitations of the traditional instructional design

models. As it can be seen from Figure 2-3, rapid prototyping continues with the parallel processes of design and research, or construction and utilization.

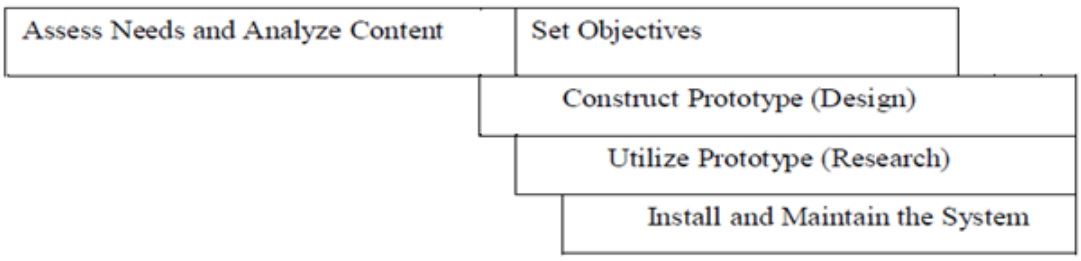

Figure 2-3: Prototyping approach to software design.

According to Tripp and Bichelmeyer, the biggest difference between rapid prototyping and traditional instructional systems design is that although many traditional models emphasize early constraining of design decisions, rapid prototyping follows the pragmatic design principle of minimum commitment, which depends on synthesizing and limiting the design necessarily only regarding the solution of the problem at hand at that stage.

MISA Model for e-learning

The MISA "engineering method for learning system" is a methodology outcome of many years of experience of TELUQ university that designs and uses distance learning since 1972 [23]. The methodology is composed of six main phases: Project definition, Preliminary analysis, Development of training architecture, Instructional design, Development and validation of training material, Preparation of establishment of the training for each phase, the precise methodology documentation elements must be written by the design team [24]. MISA offers a total of 33 documents with formats standard which can then be automatically compiled by certain learning platforms presented in Figure 2-4. in order, to help designers to write these documents, the authors have proposed language modelling called MOT [25, 26].

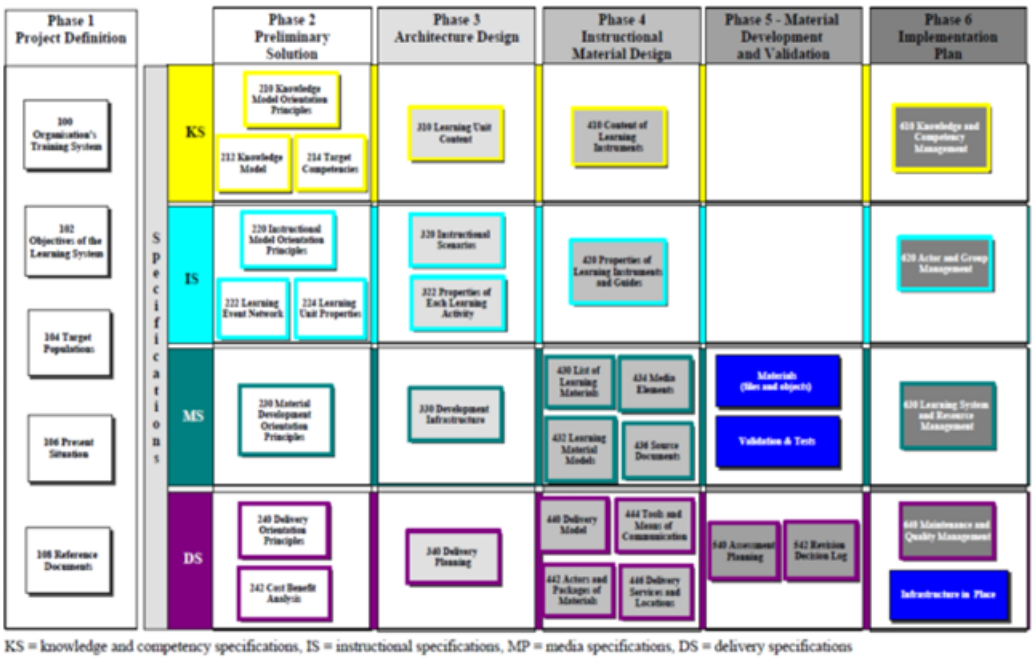

Figure 2-4: Standard documents available for each design phase of MISA.

The documents related to each phase of this method, shows the effectiveness of the method for instructional design. But these should be kept simple and easy to handle.

E-learning process

Iraklis Varlamis et al, in [16], present an e-learning process that is composed of four sequenced phases or steps, it begins from the first phase called planning and preparation of a course to the phase called consumption by the learners; the Figure 2-5 below details the full process of e-learning.

For the successful design of e-learning process, it's preferable to define the required features of learners' profile and the recommended; it should also define the pedagogical objectives that the learner must achieve by the end of the learning process. The production phase integrates the production of content modules, their build up based on the initial design, and the packaging of the content to be delivered. The deployment phase that follows should consider the ability of users to access the content and collaborate during the learning process. The learning process ends up with

the assessment of learners through tests and other activities and of the process itself through evaluation forms.

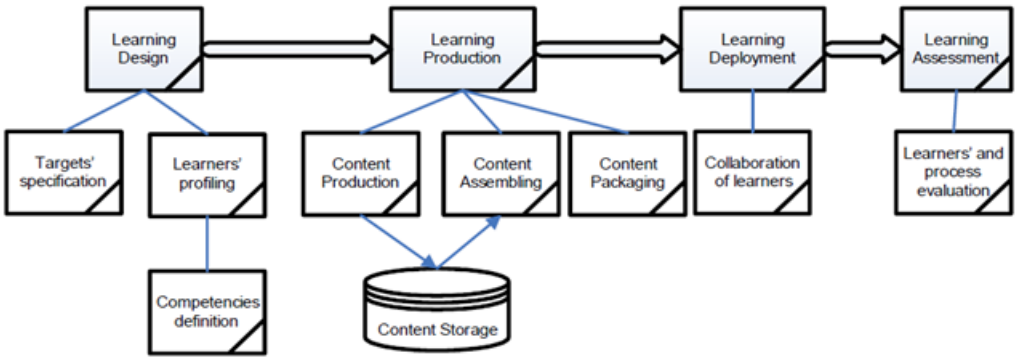

Figure 2-5: The life cycle of the e-learning process.

2.1.4 Platforms of e-Learning

E-learning systems are a web-based applications that integrates different management and communication tools, evaluation, assessments, monitoring and others utilities with the objective of providing technological support to instructors and students/learners in order to optimize the various phases of the learning process, either the educational process completely remote, classroom or mixed nature and combine both modes in different proportions. The main Features of the e-learning platforms are:

- Authentication
- Generating and management of the content
- Different media with a instructor / tutor / expert
- Carrying out activities such as tasks, group work
- Report of the activities of each action and actor
- Evaluation and assessment tools

Most of these platforms are based on different systems like leaning management system (LMS), Course Management Systems (CMS) or learning content management system (LCMS), each system has its own characteristics.

Course management systems

Suman Ninoriya et al, in [27], describe in their paper the notion of CMS or a Content Management System as a system basically designed to support educative or academic courses. It allows the instructor to create a course website, where documents can be uploaded in popular formats such as word, power point, etc. Without having to convert them to a web format such as HTML. This requires few specialized skills, thus making a CMS the ubiquitous choice of instructors. It also efficiently supports distance learning because of its robust discussion board application. Instructors post the essence of the course that leads students through varied learning activities, after which the instructors supervise course discussions through the discussion board. In a CMS, data is a term representing among others documents, movies, pictures, phone numbers or scientific information. Several CMS categories are determined depending on the content: Web content such as HTML code, digital libraries, multimedia files. There are several researchers who have given the different ideas about the use of CMS as E-learning. they conclude that the concept of content in educational institutions has not been a simple one only by definition; it depends on the context and the learning goals that must be achieved. Therefore, using CMS in educational institutions needs to face new requirements caused by two main factors: first, content granularity and typologies are very diverse, and second, content should be created and shared with reusability in mind.

Learning management systems

In [27] the learning management system is defined as a new technological resource based in web technology. Research results demonstrate that, although innovation may build upon the technical prospects, concrete difficulties arise, caused by problems of incongruity at the level of the educational model [28, 29, 30].Typical learning

management systems (LMS) integrate most common e-learning functions in a single application. An LMS is an integrated set of software/programs that automate the administration, tracking and reporting of on-line courses/programs. It provides a centralized organizational approach to learning for scheduling of courses and registration of learners, and assessment of their learning outcomes.

A robust LMS should be able to do the following:

- centralize and automate administration
- use self-service and self-guided services
- assemble and deliver learning content rapidly
- consolidate training initiatives on a scalable web-based platform
- support portability and standards
- personalize content and enable knowledge reuse

An LMS helps in running a learning organization. It does not help create or deploy content. It does not track students through a particular course. It does not enable Tutors to communicate with the students.

Learning content management systems

In general the learning content management systems "LCMS" provides a more complex platform meant for developing content used in e-learning programs. Many LCMS packages available on the market also contain tools that resemble those used in an LMS, and most assume that an LMS is already in place.

According to Paulsen, LCMS is an environment where developers can create, store, reuse, manage and deliver learning content from a central object repository, usually a database. LCMSs generally work with content that is based on a learning object model [31].

Among the LCMS functionalities there are:

- Template-driven, Collaborative Content Development.

- Facilitated Content Management.
- Publishing.
- Workflow Integration.
- Automated Interface with an LM.

Among the deficiencies that LCMS have managed to overcome there are:

- Companies need the e-learning on their own specialized procedures and processes, and by definition, generic courses don't fill the bill. For this reason LCMS come with build-in authoring tools.
- In general, learners want only part of what that course has to offer, specifically, what they want to learn. LCMS were designed to deal at the atomic level because the courses must be atomized and broken down into reasonably sized chunks.

To conclude Learning Content Management Systems LCMS were created to overcome these difficulties mentioned above, with Learning objects, those small chunks of learning, are at the heart of an LCMS. They are maintained in a database or "repository". LCMS provide authoring tools to create new learning objects for the repository. LCMS have the ability to assemble and consolidate learning objects into lengthier "learning paths" or learning experiences that are personalized to a learner's profile, etc.

The open source and the commercial e-learning software based on CMS, LSM or LCMS

The choice of e-learning software depends on the need of the users, and the properties that offer each system of management "CMS, LMS, LCMS", for this reason there are a variety of solutions that exist developed by the universities or companies. In this part we will present some of this software according to their management system.

Dokeos [1] : Dokeos, shown in Figure 2-6, is a learning web based application that allows the users to create, organize, follow and coach learning activities. Among the features of Dokeos there are: Build e-courses using templates, import SCORM courses. Assess learners through tests and surveys. Coach them through interaction tools. Convert Word and Power Point documents into courses.

Figure 2-6: Dokeos web based application for e-learning.

DotNetSCORM [2]: The main objective of the DotNetSCORM project, shown in Figure 2-7, is create a SCORM Compliant LMS to serve as a model for further development and use of the SCORM standard on the Windows Platform.

Figure 2-7: DotNetSCORM web based application for e-learning.

[1] http://www.dokeos.com/
[2] http://dotnetscorm.codeplex.com/

Moodle [3]: Moodle, shown in Figure 2-8, is a course management system (CMS) a free; Open Source software package designed using sound pedagogical principles, to help instructors create effective online learning communities. Moodle can scale from a single-teacher site to a University with 200,000 students.

Figure 2-8: Moodle web based application for e-learning.

OpenLMS [4]: OpenLMS, shown in Figure 2-9, is a Learning Management System (LMS) made at the Department of Geography, Norwegian University of Science and Technology. The system is a fully functional LMS with support for group collaboration, file sharing, distribution of lectures, etc.. As such it is a good tool for distributing lecture notes to groups of students, and also facilitates collaboration for groups of students and teachers.

Figure 2-9: OpenLMS web based application for e-learning.

[3]http://www.moodle.com
[4]http://www.openelms.org/

MOS Chorus [5]: MOS Chorus, shown in Figure 2-10, is a Learning Management System (LMS) and a Learning Content Management System (LCMS), in one. This collaborative platform is a 100% web-based, multilingual, SCORM 2004 compliant solution for creating and distributing eLearning content. It offers a richer and broader set of tools and commands for creating learning content, editing graphics, administering the platform, monitoring user progress and reporting.

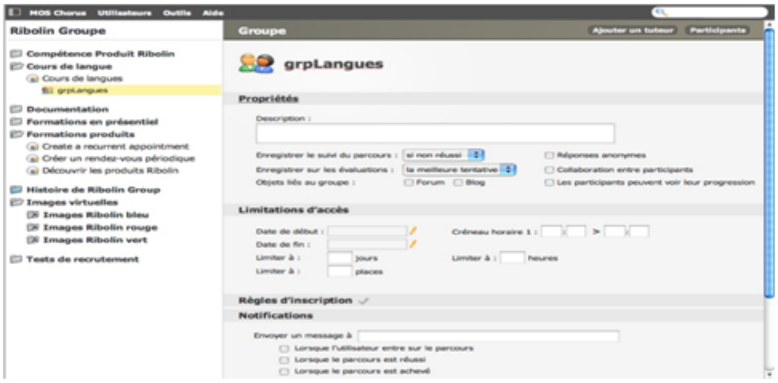

Figure 2-10: MOS Chorus a web based software for e-learning.

CERTPOINTVLS [6]: CERTPOINTVLS, shown in Figure 2-11, has been consistently rated by the top industry analysts as the most comprehensive turnkey LMS/LCMS solution for mid-size to large organizations. Using CERTPOINT'S SCORM compliant web-based technologies and services, our customers realize a reduction in training costs, quicker product introductions, and a consistent and measurable means of training their employees, distributors, customers and partners.

[5]http://www.mindonsite.com/en/produits/mos-chorus/
[6]http://www.certpointsystems.com/fr/

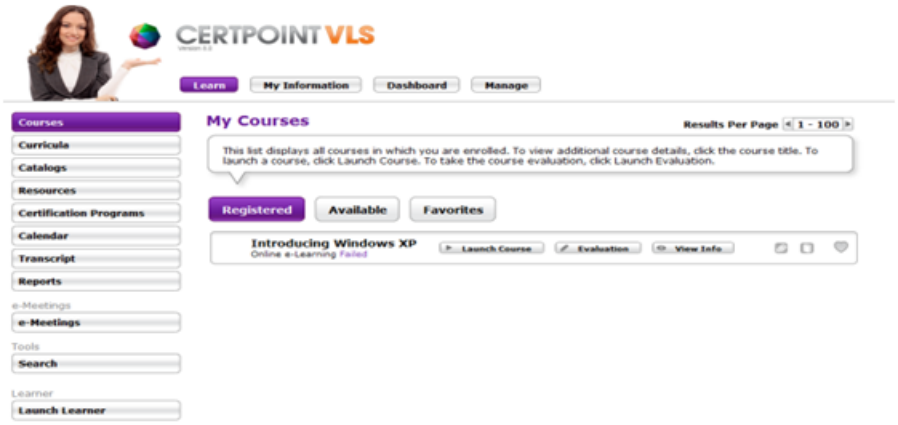

Figure 2-11: CERTPOINT VLS a web based software for e-learning.

eXact learning LCMS [7]: eXact LCMS, shown in Figure 2-12, is the industry reference Learning Content Management System LCMS, that responds to today's varying business pressures, supporting instantaneous, company-wide collaboration for the creation of critical learning content. eXact LCMS maximizes your existing content investments, while supporting learning content strategies that improve your key business processes.

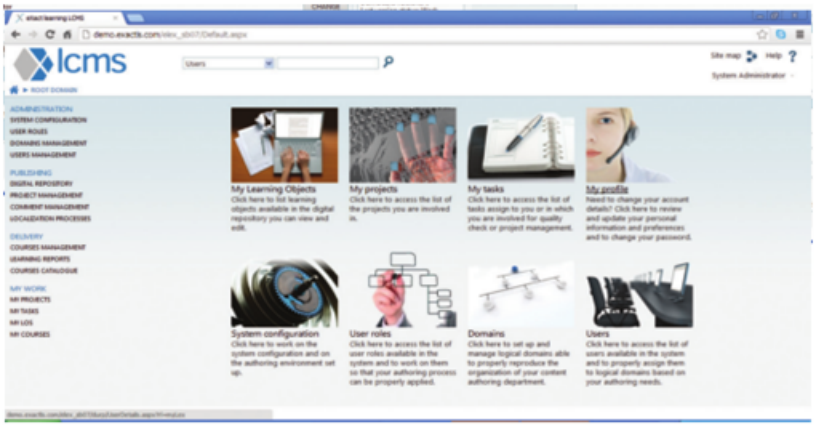

Figure 2-12: ICMS a web based software for e-learning.

What we can conclude from this section is that there are several solutions for e-Learning based on the three management systems detailed above, this variety of

[7] http://www.exactls.com/en/home

solution leaves a great choice for the users to choose the solution that meets their need.

2.1.5 Conclusion

E-learning has become one of the most popular tools for distance learning thanks to the advantages that it presents; the diversity of web applications based on different management systems offer great margin for the users to choose the web application that suits their needs. But these recent years have known a new revolution concerning E-learning and especially with the appearance of video games dedicated to the learning, in the next part we will detail this kind of video games called serious games.

2.2 Introduction to serious games : A Survey

2.2.1 Video games as pedagogical devices

Since the mid 1980s video games have become one of the most significant activities of the lifestyle of the younger generation, they raised legitimate questions from parents and instructors. This new trend has caught the attention of researchers and pedagogical experts to use video games as pedagogical devices to transfer knowledge to the learners, with the affirmation of several researchers that the relation between entertainment and pedagogy can be possible via video games. Several research works have been done in this way, among the more interesting research works there are Gilles Brougre [32].

Gilles Brougre in his works has distinguished three types of relation between games and education. In the first place, it comes to recreation. The video games are an essential effort in general relaxation especially academic effort. Secondly, the interest shown by the learner to play must be used for a good cause. This is the game as a teaching trick. Finally, the game allows the teacher to explore the child's personality and possibly adapt to it the teaching and guidance of the student. In these three types of relationships, the game has been used to make a less painful effort, and it is this principle that is sought in video games that will be used as educational devices.

With this relation that exists between education and entertainment, educational world very quickly saw the benefits of the use of video games to address some concepts with learners, especially as it is ultimately one of their favourite methods of entertainment. The video games camp plays an extremely important role as pedagogical devices, they can teach topics and are especially effective for dealing with problems solving and key concepts. According to different studies games have a special role in building students self-confidence and they can reduce the gap between quicker and slower learners [33].

Through the video game, learners become central actors in their training as opposed to the passive position they occupy most of the time in mainstream education,as shown in a study by the National Research Council [34]. In the next part we will

discuss in details this kind of video games dedicated for learning, also called serious games. The learner finds himself engaged emotionally in the game, thereby facilitating its impregnation actions and decisions in his memory.

2.2.2 Definition of serious games

Since the emergence of serious games during the 80's and until today several definitions of serious games have been appearing. For this reason there is no universal recognized definition of serious games, Susi et al [35], therefore, according to different studies we can define a serious game as a video game used for purposes other than mere entertainment. Several researchers and laboratories have defined serious games this last decade; these definitions depend according to the context for each use case, among the most known definitions, there are ones mentioned below.

Zayda, in [36], has proposed a specific definition of serious games, in his definition he presented the serious games as a mental challenge against a computer involving precise rules, and based on entertainment to achieve goals related to institutional or professional training, education, health, domestic policy and communication.

One year later in 2006 Chen and Michael, in [37], have proposed a new definition of serious games as any game whose primary purpose is smoothing other than mere entertainment.

In 2007 several research works lead Sawyer, in [38], to refine his own definition of serious games as any relevant use of technologies from the video game industry for purposes other than entertainment.

In 2011 Djaouti, Alvarez and Jessel, in [39], define serious games as a game which has a non-entertaining primary purpose, thus making it serious.

The term serious game includes many types of games that are distinguished by their application context. Several taxonomies exist, with that of Sawyer and Smith, in [40], that define seven type of objectives and as many fields of application, which lead to several types of serious games. Among them there are:

- advergames, which are advertising games.

- Learning the Games, which include building skills.
- The Games for Health aimed at improving the health of the user, via awareness or information thereof, or exercises.
- Games for the training, serious games training using the simulation.

A large part of the thesis will be devoted to learning games "LGs" for they are video games that involve building skills. The learning games are a sub-class of serious games in which the features of the game are used to promote mechanical learning. Furthermore, the LG are used in a school context or vocational training. This genre of video games offers a unique structure to complement traditional teaching strategies and infuse teaching with energy, spark innovative thinking and provide diversity in teaching methods. Games make learning concepts more palatable for students and supply learners with a platform for their creative thoughts to bounce around. Games encourage creative behaviour and divergent thought [33]. The LG must have an explicit educational purpose and are well integrated training [41].

However, in order that the LGs have good results on the students learning, they should foster motivation, that motivation implies that the learner must be totally immersed in the LGs, and he must be conducted only by his pleasure in it. To make the balance between the educational and fun aspects, the LGs must be focused in one side on scenarios that can combine both aspects, and on the other side on gameplays which are the fundamental units of video games. In the next section we will describe and detail the notion of gameplay.

2.2.3 Definition of the gameplay

The term gameplay can be ambiguous to define, thus it has been differently defined by different researchers and authors. The most known definition of gameplay is that the video games are based on small unities called gameplays; these unities allow the interaction between players and video games, the gameplay as unity is defined through the game rules. The literature proposes multiple definitions of the gameplay, among them there are the definitions described below in a chronological order.

In 1998 Banks, in [42], has defined gameplay as a term that emerges in the most discussions between players and game designer. It is a quite incoherent concept that is used to describe the experience of a gamer's visceral immersion in and interactive engagement with a particular video game's environment.

In 2002 Marc Prensky, in [43], who defines gameplay not only as the game experience, but also as the set of strategies used by game designers and game developers for engaging gamers and keeping them motivated to play more and more.

In 2005 Jesper Juul, in [44], believes that gameplay is not a mirror of the rules of video games, but a consequence of the game rules and the dispositions of the game players.

In 2008 Miguel Sicart, in [45], defines gameplay via game mechanics, since it would be composed by methods Invoked by players or computational, to interact with the video game environment.

In 2009 Arsenault and Perron, in [46], who build a concept of play based on their idea of gameplay, think of this term as a junction between two different entities: game and gamer.

According to the gameplay definitions above, we notice that the authors emphasize that the concept of gameplay cannot be defined using only the notion of fun. Gameplay would be understood in a range of possible actions and reactions generated by both the gamers and the video games. For this reason game designers have to design their video games, taking into consideration the gameplay mechanics that suit them, to have the intended result. To conclude the main objective of the gameplay concept is to motivate and attract players attention and to make a strong interaction between players and video games.

2.2.4 The advantages of serious games

The serious games have several advantages and benefits; these advantages concern many areas of application, in the literature there are various papers that have discussed the advantages and benefits of serious games, we will detail below some benefits cited in different studies and papers written by several researchers. The serious games

allow learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc. [47, 48].The serious games has promoted the learning over the years , this conclusion has been conducted by several analysis [49]. According to Mitchell and Savill-Smith, in [50], games can support the development of a number of different skills.

Raybourn, et al [51] have mentioned in their paper that serious games provide the opportunity for experiential learning and they provide an environment for active, critical learning. In the papers of Raybourn et al and Caird-Daley , in [52], among the benefits of serious games mentioned in these both papers, there are costs, outcomes and rewards of alternative strategies that result from decision making.

In 2010 Kaplan EduNeering, in [53], has written in his paper that Players either inherit a strongly formed and appealing character or they get to build a character from the ground up. Players become surrounded with obligations to the new virtual world in which they will learn and act.

Other potential benefits of serious games include improved self-monitoring, problem recognition and problem solving, decision making, better short-term and long-term memory, and increased social skills such as collaboration, negotiation, and shared decision-making [54, 50, 55].

In addition to what is already mentioned above, other benefits of serious games are: Gamers develop their thinking strategies towards more analogical thinking rather than trial-and-error thinking [56] and that game elements such as competitive scoring, increasingly difficult levels, and role playing have proven useful in corporate training [57]. Yet another advantage is pointed out by Squire and Jenkins, in [48], who argue that games can be a powerful way of introducing new concepts and tie together disparate periods of history.

Sitzmann and Ely, in [58], who have written in their paper that in a meta-analysis found that learners participating in simulation game learning experiences have 11% higher declarative knowledge, 14 % higher procedural knowledge and 9% higher retention of training material than those trainees participating in more traditional learning experiences. Increase in learner knowledge, recall and retention of content due to in-

creased frequency of Sinteracting within a game due to motivational factors and due to the fact that the learning takes place in a realistic environment.

Caird Daley, in [52], has mentioned in his paper that in military training, Serious games also provide students with a safe benign learning environment which enables students to explore decision making under a range of hazards and in dangerous activities and to learn from the outcomes of their actions without risk to life or equipment. They enable training to take place 24 hours a day, seven days a week regardless of weather conditions; and without damage to the environment [59]. They can be easily tailored to the skill levels of the training audience and are readily accessible. In military training, it is acknowledged that serious games, just as with simulator training devices, have limitations, for example they cannot replicate morale, fear, fatigue or physical adaptations to extremes of climate which are best trained in the live environment. This does not undermine the use of serious games for military training, but acknowledges that serious games are not the media solution for all training needs.

2.2.5 Conclusion

Serious games especially learning games as e-learning tools have a very important impact on learning of learners , this impact is due to the advantages and benefits that such video games represent, with the confirmation of different studies in the literature. The serious game marks the entry into the video game services company offering practical and theoretical knowledge, not without economic and conceptual difficulties. Such as speeches combine the rhetoric of learning and the progress they allow both to establish markets and finally to highlight the plurality of serious games. The question that arises now is are there any design methodologies for such video games ?

2.3 Game design for serious games : A Survey

2.3.1 Definition of the game design

The term "game design" has several definitions that depend from a researcher to another; the simplest definition is that game design is the act of deciding what a game should be. Another definition is that of Salen and Zimmerman, in [60]; these two researchers define the game design as a process by which a designer creates a video game, dedicated to be used by a player, to be born a gaming experience, this definition is vague due to the exact nature of this process. In the video game industry, the game design is a process designed to invent rules of the game. The purpose of this step is writing a kind of a document called game design document [61, 63]. To understand better the concept of the game design we should know the tasks associated to the game designer during the game creation process, the game designer generally focuses on the invention of the rules and the game world, the definition of the gameplay or the mechanics of the game, the adaptation of the game story to be playable, in addition, to other important tasks for the development of the game.

The game design of the serious games is the same as that of the entertaining video games, the only difference is that the game designer in this kind of video game should consider the educational aspect, and therefore, he must introduce the educative messages and educational objectives in the video game, in a way that the game keeps its entertaining aspect. In conclusion, we can define the game design as a primordial phase that belongs to the process of the video game creation, and that involves different tasks done by the game designer in order to develop playable video games or serious games.

2.3.2 Serious Games design methodologies

We have defined a serious game design as the process that is composed of several phases in order to create serious games. Until today there are several methodologies of the game design established or created by different laboratories, institutions and

the professionals in the field of the video games industry, and that creates a diversities of choices for the game designer, in this part we will detail some of these game design methodologies used by several game designers in creating both entertaining video games and serious games.

A model of industrial game design based on educational engineering

The team of the learning game factory, in [63], has proposed a model related to the process of the serious game design in Figure 2-13. This model begins with the specification of the pedagogical objectives "pedagogical content" with the cognitive experts and the field experts, then the pedagogical expert designs the serious game; the operation will be detailed through several documents. The team has developed a technical tool dedicated to support the model; the tool is composed of widgets to formalize an aspect of Serious Games, and also to create the serious game scenario according to the IMS Learning Design formalism. This formal model of educational engineering allows representing educational structures. The main advantage of formalizing a pedagogical scenario is the ability to automatically evaluate with dedicated technical tools.

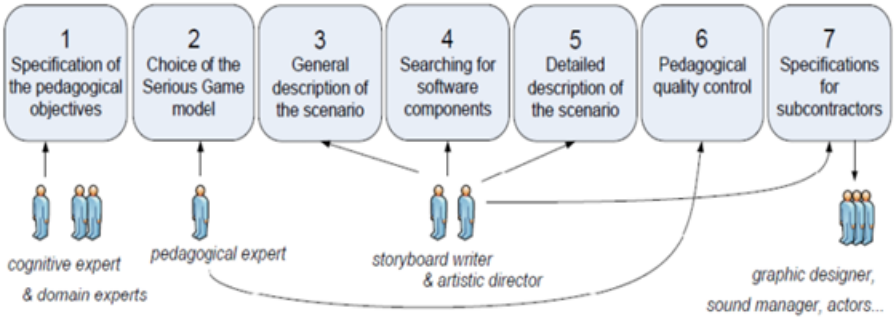

Figure 2-13: The design model of a serious game proposed by Marfisi Schottman and al.

As we can deduce, this formalizing process is inspired from the teaching engineering and it focuses primarily on the creation of video games for the field of education, in addition, it shares the concepts with other models, such as using an iterative process or the definition of a serious content prior to the game design itself. We notice

the absence of the game designer in the actors involved in the creation of Serious Games according to this model.

Industrial model of KTM Advance

The company KTM Advance specialized in the establishment of the video games uses also a model, shown in Figure B-1 for the design of serious games [64].

The KTM Advance model consists of five complimented steps in order to create serious games; the model begins with a step called needs analysis [A], in this step the designer defines the technical and pedagogical features of the Serious Games. The use of the concept note summarizes the educational needs of the customer, in order to define the pedagogical content. Afterwards an analysis of the content is done, and the different elements of the content are grouped in a hierarchical list.

These element grouped in this step will be used in the proposition of the game design step [B]; during this step the designer invents the games mechanisms to transmit the content, this proposition is detailed in different aspects e.g. "scenario, gameplay, etc.", in a specific document.

After the game design step comes the prototype development step [C], in this step the programmers realize a prototype of the game. The prototype realized can test the relevance of the proposed mechanisms related to the pedagogical objectives defined in the first step. The game is developed according to an iterative process in the iterative deliveries step [D], in this step the customer sends a list of modifications, after the test that he has done on the submitted game. As final step called final delivery [E] the users test the game to ensure the relevance to the envisaged objectives.

Finally we can say that the process adopted by KTM Advance is similar most of the models formalizing the entertainment video game design process, the methodology emphasizes the importance of the initial definition of the pedagogical objectives. In addition, this methodology provides a binding phase between educational structure and its implementation of entertaining scene.

The DODDLE Model

Several serious games design methodologies were inspired from the instructional engineering and more especially the generic model ADDIE, among these models there is The Document Oriented Design and Development of Experiential Learning DODDLE [65]. This model is composed of the four steps described in Figure B-2. The model begins by the situation analysis; designers must describe in this step the objectives of the serious game, the learning methodology, and the profile of the learners. McMahon has used this model to guide the novice students in creating Serious Games. The model defines a common basis to facilitate communication within each group of students. It proposes a complete series of steps for the creation of Serious Games; it allows guiding the creative process of people who have never made a serious game before.

Then comes the design proposal step where the designers must list the educational concepts, the type of game they wish to use and challenges of the serious game. Afterwards there is the design documentation step, in this step the game designer must describe the detailed scenario of the serious game, the interfaces and interactions. The final step is the production of documentation. These steps consist of describing the storyboard of the serious game; they give the global specifications and describe the game mechanics and variables. The strong point of this methodology is the fact that it gives a very important place for the specification of pedagogical objectives.

The Paraschool Model

The company Paraschool has proposed another industrial model, in Figure B-3, for the design of serious games for educational purposes [66]. This model is composed of three main steps; the first step of the proposed model refers to the preliminary work of the designer: to determine the objective of the project, identification of pedagogical objectives, etc.

As a second step there is the general design, during this step, the designer has to develop the important points concerning the principle of the game for transmitting

educational content. Among these points there are the video game genre, the game world, the objective of the video game and characters. In the detailed design step the designer creates all the games rules, graphical interfaces, gameplay, and game mechanics, etc. This step results in the creation of a complete video game that meets the objective envisaged by the designers. By using this method the created serious game will be tested in intern, until the validation of the final consumer. This model of Preschool Company illustrates the influence of computer engineering methods and especially the cascade model on the design of Serious Games.

The GEDRIVER process

The Gedriver process, in [67], is a design methodology conceived by the OKTAL Company in order to create serious games, this process is composed of four steps, and the process begins by the step that defines the pedagogical content; in this step the designer writes the reference documents about the game, this document will be formalized in meetings and discussions with other partners. The next step in the Gedriver process is the definition of the game concept, the second step consists developing the concept of the game according to the pedagogical content defined by the partners. This game concept and the detailed description of its mechanisms will then be formalized on paper so that developers can build the prototypes. The description of the game mechanisms in this step is done in the following manner by specifying the several Gameplays. These gameplays, in Figure 2-14, are composed of two main components: the Game Design and the Level Design. Each of these components consists of several parts which will be clearly specified in the document e.g. “the game modes, evaluations, mechanisms, gaming assistants and scriptwriting events”.

The components of the game design and level design are detailed in order to define the game characteristics with precision. As the next step of this model there is the level design that is designed to invent scenarios featuring the game mechanics. Specifically, it is about building the different levels of the game. The level design was held on the paper or in a Word document respecting a defined formalism. Once the

design steps are completed, the rest of the process involves making a prototype to evaluate the relevance of the Serious Game. It's the final step during the process; in this step the programmers develop the prototype in an iterative way.

Figure 2-14: The composition of the gameplay according to Gedriver.

This process continues until the return of the user matches the objectives of the designer. A conclusion concerning the Gedriver process, according to its different steps, we notice that this model has several common features with other game designs process, like iterative process, this step concerns not only the game design but also the level design.

EMERGO Methodology

The team composed of the three universities of the Netherlander has created the EMERGO methodology [68] that concerns the creation of serious games for the higher education, the type of the game created according to this model is investigative where the player has to solve a problem. The methodology is composed of five steps presented in Figure 2-15:

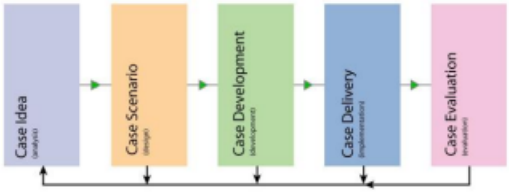

Figure 2-15: The EMERGO Methodology composed of five steps.

As shown in Figure 2-5 the methodology is composed of five steps, these steps are done iteratively. The first step in the methodology is the case idea; during this step the instructors must define their pedagogical objectives and the context of the use of their serious games. After this step, comes the scenario design step where the instructors must describe each scenario; in a scenario there are three levels of description, as a global scenario description, a detailed scenario description and the specification of each screen e.g. "editor QCM, chat tool, taking notes, etc". In the development step, the development team realizes the serious game then it will be tested by the users to remove all programming errors. The final step of the methodology is evaluation, during this step the instructor returns to its list of educational objectives defined at the beginning of the project and verifies whether the LG responds well.

The EMERGO methodology is characterized by clearly defined steps, the definition of the pedagogical objectives in the beginning of the process will help the instructors to verify the achieving of the pedagogical objectives during the final validation step.

A model centered on content

The model centred on content has been proposed by Moreno-Ger et al, in [69]. This model concerns the video games that allow the dissemination of the educational content in a relevant way. The researchers propose a series of steps for the creation of a serious game, described in the Figure 2-16.

This model draws from the rational unified process a process used in software design; this model is therefore based entirely on an iterative cycle, which requires technical tools to evolve at the same time as the design of serious games. There is a language which is defined in the beginning. This language is made up by the different elements that characterize an adventure game e.g. the avatar, the multi-choice dialogue, etc., it has a formal representation that allows designers to record their ideas in a document respecting a precise formalism. This formalism is a XML document composed of several tags referring to each of the elements of the language; this document will be transformed into serious game. However, each iteration of this

model does not necessarily result in a usable product. Unlike other models using iterative cycles, each cycle here allows gradually advancing the achievement without arriving at a game completed at the end of a cycle.

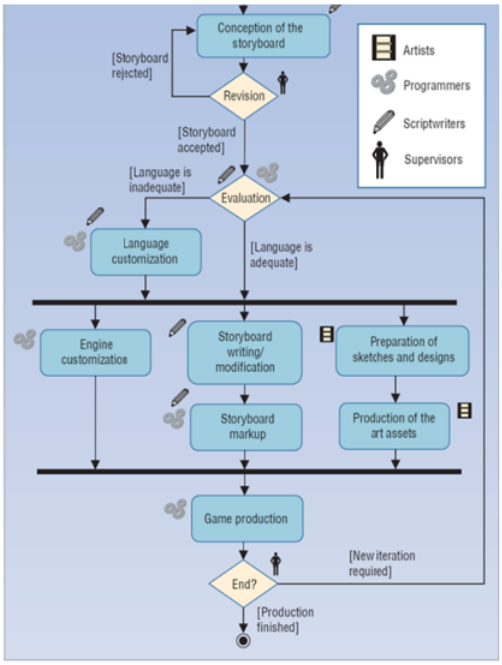

Figure 2-16: The theoretical design model.

A model for the design of learning video games

Among the methodologies dedicated for the multimedia production there is the methodology proposed by St-Pierre, in [70], this methodology consists of creating a multimedia project in an easy way, thanks to its production process that is composed of three main phases described as follows; the first phase is the Analysis and design, this current phase is composed of three steps, the first one is the needs analysis to identify and define the objectives of the product, the second step is the creative development with developing a multimedia scenario and the third one is the documentation that is drafting a concept paper describing the operation of the product to allow manufacture. After the analysis and design phase comes the phase of production and validation that consists of producing the graphical and sound elements, the development of functional prototype and the tests and evaluation and Product correcting an

iterative process. The final phase is Dissemination and Maintenance.

The same remark in other methodologies can be applied to this model. The researcher does not propose the model as a specific production process of Serious Game, because he considers it as a multimedia project. This model seems to be similar to the practices of educational multimedia sector; it seems to aim for a more general methodology than other ones. In addition, the researcher proposes in this model several design tips for each single step in the model.

CRAWFORD approach

Crawford, in [71], has proposed a series of phases that formed the game design process; this approach is composed of five phases. Starting with the first phase where the game designer must define the objective reflecting on the emotions he seeks to produce players while defining a subject for the game. The phase of research and preparation allows the designer to document on the subject to be covered by the future game, afterwards, comes the design phase, this phase consists of creating three game aspects, like input output interfaces that allow communication between player and the game, the game rules, and the software architecture. The third phase is the evaluation design; the main task in this phase is the evaluation of the quality and the consistency of the three aspects created in the design phase.

The fourth phase in the proposed approach is the pre-programming phase; it's the phase of the production of the game design document. Then comes the fifth phase, the programming phase where the technical realization of the video game occurs by means of a programming language. The tests phase is the phase where the players can declare the eventual latest faults. The final phase is The Post-Mortem where it is important to listen to criticism of the players and the specialists because they can be beneficial for the creation of a next video game. As conclusion of Crawford approach, it's a model with the clear phases that lead to the creation of the video or serious games. The method can be used by any team composed of a game designer and game programmers.

ADAMS approach

Like the other methodologies described in this section, Adams, in [72], proposes an approach presented in Figure 2-17, which aims to encompass all variants of the game design, the Formalization of the game design process is based on three steps. The first step called the design where the game designer defines the general principles unchangeable during the rest of the process, the next step is the elaboration, this step is devoted to the definition of all the rules of the game, as well as the creation of the prototypes. The last step is adjustment where the game designer will fix all the problems of his video game. The unique specificity of this model is the fact that the transition between each step is clearly defined, by cons it's iterative as the other processes specified in this part. En general, the use of this process is easy, that allows the non-experts in the game creation field to create their own video games.

Figure 2-17: The design process proposed by ADAMS.

2.3.3 Conclusion

The design of both serious games and video games requires a design process with clear and detailed steps, several approaches and methodologies mentioned in this part have been created by different institutions and companies specialized in the video game industries, which means that each approach has its own characteristics, most of these methods have one thing in common which is that they are based on iterative process, where each step has a particular task with the aim to create the envisaged video game. Until today there is no standard that unifies the deign process of serious games, that causes the problem of which is the best method that will allow the gain of time and cost of realization.

2.4 Game engines and game generators : A Survey

2.4.1 Game engines and game generators

The game engine [8] is a combination of modules, tools, APIs and interfaces that allow the game programmers to focus on product video game content, rather than technical content, more specifically the game engine is a complex system designed to visualize video games, to provide resource management, animation, 2D or 3D rendering, physics, sound, collision detection, scripting, Artificial intelligence, networking, etc. there are several game engines developed until today, most of them are developed by using different programming language e.g. "C, C++, Java, JavaScript, etc.", and they allow the creation of several video games in different platforms e.g. "Windows ,Unix, Web, Android, etc.". In the next section we will detail some game engines often used by several experts in video game industry.

Most game engines includes several features rendering engine (2D/ 3D), scene graph, collision detection, physics engine, scripting, animation, artificial intelligence, sound, networking, streaming, memory management, threading, etc. There are no a unified game engine architecture design. However, many games engines will offer certain functionalities and define common types of components see Figure 2-18 that presents the basic game engine architecture implemented in the most game engines.

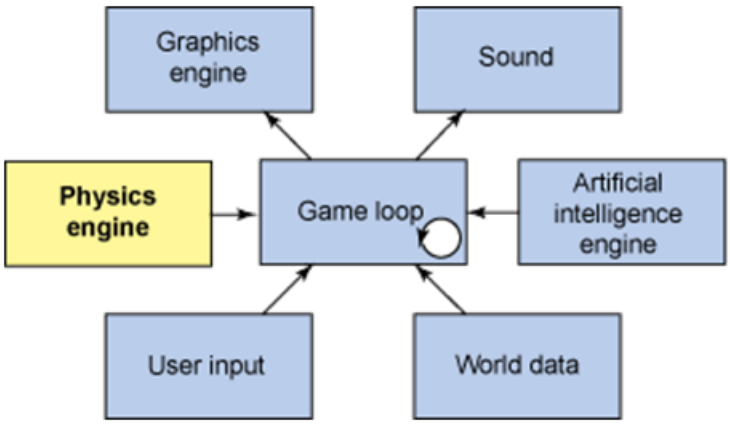

Figure 2-18: The basic game engine architecture.

[8] http://en.wikipedia.org/wiki/Game_engine

Cocos2d

Cocos2d[9] is a suite of open source, cross platform, game development tool to build several video games. This game engine has been written in C++ programming language, it contains many branches as Cocos2d-SpriteBuilder, Cocos2d-x, Cocos2d-html5 and Cocos2d-XNA. Broadly speaking Cocos2d is a very complete framework, it's free, and it's among the most used game engines nowadays, the game developers that use Cocos2d can adapt, modify the code according to their needs, It has a good physics engine, a large developer community that supports it and improves it. The only negative point of this game engine is the programming language C ++, that makes the realization of video games through this engine more difficult for the people unaccustomed with the C ++ language. Cocos2d remains among the most reliable game engines, thanks to its advantages.

jMonkey Engine

jMonkey[10] is an open source game engine dedicated to the creation of cross platform 3D video games "serious game", it's written in Java programming language and it's based on LWJGL[11] as its default renderer. jMonkey has a SDK based on Netbeans Platform. The fact that jMonkey is developed using Java so it possesses all the advantages and disadvantages related to Java programming language. The jMonkey rendering system is entirely based on shaders to fully take advantage of hardware acceleration, it has very active community, which makes this game engine a good choice for achieving a cross platform video games. Thanks to Java, jMonkey becomes among the easiest game engines for developers.

Libgdx

Libgdx[12] is a framework developed in Java programming language with some C and C++ components for performance dependent code, with the aim to create several

[9] http://www.cocos2d-x.org/
[10] http://jmonkeyengine.org
[11] http://en.wikipedia.org/wiki/Lightweight_Java_Game_Library
[12] http://libgdx.badlogicgames.com

2D or 3D cross platform video games. Just like the other game engines mentioned above Libgdx has an active community. Based on experience gained during the use of the game engine we have noticed that the architecture of Libgdx for the game development is too well built, but there is a lack of documentation and information, and there are few sample codes but it doesn't implement all Libgdx, and there are some methods that don't have documentation and the developer must test them and know how they work. According to both advantages and disadvantages of this game engine and also the feedback of the users, we can say that Libgdx is a game engine that needs more evolution, there is much work to do especially on the 3D side for it to be able to compete with other solutions that exist.

Unity

Unity[13] is among the popular game engines in the video games industry, it's cross platform, and it's written in several programming languages like C, C++ and C#. There are two versions of Unity: Unity Pro is available for fee and Unity Personal has no fee. According to our acquired experience during the use of Unity game engine we notice that Unity has a lot of things that make the creation of video games easy, among these things there is the possibility of developing via JavaScript, C# or Boo programming languages, it has a Great community support, it allows to build cross platforms video games in an easy way, and Easier to make video game interfaces and scenes as compared to other engines. Unity has some disadvantages, among them there are: Unity is not free, Developers have a hard time wrapping their heads around the work-flow, and less experienced developers. Given its popularity of and dynamism of its community Unity does not cease to make increasingly large user base compared to other game engines.

[13]http://unity3d.com

Unreal Engine 4.x

Unreal engine[14] is a game engine developed by Epic Games, in order to create video games according to the First Person shooter style, it has been used in a variety of other genres, including stealth, MMORPGs, and other RPGs. The proposed game engine is written in several programming language like C++, C#, GLSL, Cg, HLSL, it has several features as rendering, collision detection, AI, visibility, networking, scripting, and file system management. Like other game engines, Unreal has several advantages: Nice Graphics Quality, very easy to learn for beginners, it has Physically Based Rendering built into its core rendering pipeline, it means the developer can made a lot more realistic and stunning visuals.

Nevertheless there are also disadvantages, among them it's has a proprietary license for the versions 1 until 3 but both Unreal Engine 4 and Unreal Development Kit (UDK) is free. Despite some disadvantages of this game engine, it's one of the most solid and stable game engines in the field of industry videos games, thanks to the experience that epic games company has acquired over the years and the strategy of the evolution from one version to the other followed by the company.

Pixi.js

Pixi.js[15] is a game engine based on JavaScript programming language, webGL [16](Web Graphics Library) a JavaScript API for rendering interactive 3D computer graphics and 2D graphics, and HTML5 canvas. This game allows the creation of small web-based video games especially the platformer genre, all of the created games can be run in different navigators. It has several features like other game engines existing in the video game production field e.g. "rendering, collision detection, sound, AI, visibility, scripting, etc.", Pixi.js benefits from the features and advantages of webGL.

[14]http://www.unrealengine.com/what-is-unreal-engine-4
[15]http://www.pixijs.com/
[16]http://en.wikipedia.org/wiki/WebGL

CopperLicht

CopperLicht[17] is a commercial JavaScript 3D engine for creating games and 3D applications in the web-browser. It uses the WebGL17 canvas supported by modern browsers and is able to render hardware accelerated 3D graphics without any plugins. The CopperLicht has a full 3D world editor named CopperCube; it allows the creation of 3D video games without programming. Among the features of CopperLicht there are: 3D Graphics features, Collision detection, Character animation support, and web/HTML/JavaScript features. In general the documentation is good. However, it's preferable that each item should include one or more examples of how to use it. CopperCube editor doesn't export some models e.g. "Collida models". Despite these drawbacks, it remains among the most reliable web-based game engines.

Target platform

TARGET platform[18] consists of several software components, tools and utilities, designed to support self-directed learning. It's also a digital educational game (DEG) presented within a 3D virtual environment. This DEG consists of a set of game scenarios related to the knowledge domains. The approach of target platform begins first with the learner that is provided with a description of the game scenarios, the description of the main objective and the role descriptions of other characters in the game. The learner can use several tools in order to finish the game scenario successfully; the use of these tools involves the interaction of artifacts and the communication of different characters to collect the information. The target games scenarios offer a large set of possible actions released by the learner. This platform based on game scenarios offers many opportunities for the users to create several serious games within the limit of the features offered by the platform.

[17] http://www.ambiera.com/copperlicht/
[18] http://www.reachyourtarget.org

mEditor

mEditor, in [73], is an editor for serious game-based learning design, created through mEducator project, the framework uses mEditor scenario editor that mixes between visual programming and workflow management, letting designers, model how the game should react to user input, the serious game editor offers the flexibility and the ability to the educators to create serious games to serve their learning objectives. The model is represented as a directed acyclic graph, and is stored in simple XML files.

These files are read by the game engine that will run the scenario, calling at the right moment its own dedicated functions that were declared to the scenario editor. Among the advantages of this editor there are: The scenario can be edited and manipulated without programming knowledge, it's just enough to manipulate the menu and the actions via the drop down lists provided in the editor. The proposed editor can be used with any game engine, by developing the several programs that interprets the XML files coming out of the scenario editor and then will be included in the target game engine. The developers and the designers mention that the approach adapted by the mEditor and mEducator will assist towards reducing the development costs of serious games and expand the application fields by creating reusable games and game tools for both to game developers as well as to the organizations that implement them.

LUDOCORE

LUDOCORE, in [74], is a logical game engine based on event calculus; it allows linking game rules to the formal logic used by automated reasoning tools in artificial intelligence. It serves as a bridge from the concerns of game design to logic-based Artificial intelligence tools; it has also served as the basis for implementing interactive prototypes. The main goals in building LUDOCORE is to have an automated game design system that can manipulate game rules, and a game-design prototyping system that provides designers quick feedback and deeper insight into early stage designs. It provides a powerful representation for the game and the design expectation, the

logical game created by the LUDOCORE can enable a variety of uses, and it provides intelligent feedback that helps designers to solve design problems. The proposed game engine requires logical skills, which will cause problems for the users who don't have command of logic reasoning.

Open Wonderland

In the health care field there is Open Wonderland[19] a tool-kit for building 3D virtual worlds, it's designed primarily for developers familiar with the Java programming language and allows theme the creation of dynamic learning environments, collaborative business applications, or interactive, multi-user simulations. The developers and designers can extend Open Wonderland's functionality to create new worlds and add features to existing worlds. The Open Wonderland community is active, the core project are published and discussed on a regular basis. Since it's based on Java programming language, Wonderland benefits from the strong points of the Java, and Wonderland programming is accessible to a large number of students and software developers.

It has also the ability to easily bring in existing content by dragging and dropping several animations and objects. Among the cons of open wonderland is a required level of expertise, therefore, for the non-experts creating video games through Open Wonderland can be difficult for the first time.

<e-Adventure>

<e-adventure >, in [75], is a platform developed in Java programming language, based on a XML interpretation engine and a graphical user interface that allows the creation of the games graphically, dedicated to facilitate the creation of adventure serious games, realized as part of a research project of the Complutense de Madrid University. It works like other tools that create adventure games, to understand the concept of this platform, it's important to describe adventure video games, this kind

[19]http://openwonderland.org/

of video games is composed of several scenes related to each others. Each scene is constructed with objects and characters.

The interactivity of the adventure games is based on rules for each object and character, the simple rule is composed of conditions and actions. According to the definition of adventure game the process of creation thought this platform begins when the user chooses a condition from a predefined list, then associate divers actions e.g. "add objects, change scene, or establish a conversation, etc." to the chosen condition. Concerning the conversations, they will be related to each character via a dedicated editor, each conversation is composed of several phrases. The video games created through this platform can be integrated into LMS via the Scorm standards. There are some advantages in using e-adventure platform. It's easy to non-experts to create adventure video games, it has also a low learning curve, it's light enough to be run in any computer; however the simplicity of this platform may limit the creativity, the community support is very limited, few people working with this platform, and it's limited in one game genre "adventure".

VIRTUOSO

VIRUSO [76] as <e-Adventure >allows the creation of 3D adventure serious games; it's realized by an American research team from North Carolina State University, VIRUS is based on source engine and some tools that allow the modification of several game aspects. VIRUSO possesses of a level editor that allows moving freely in a 3D world and adding objects to create a level. It also has a 3D objects library to make the task easy for the instructor and avoid the complexity of modelling such objects. This tool facilitates also another aspect related to the creation of the game rules, each rule is based on a system of condition and action. For each object that belongs to the level, the instructor can associate to it specific actions and conditions. Another functionality that makes this platform interesting is its ability to collect information about the learners and save them in a database; these data collected from learners will be used by the instructors to evaluate their level. It also adds the ability to develop games in a collaborative way thanks to the Half-Life 2 networking features.

2.4.2 Conclusion

With this diversity of game engines, game platforms and game generators described in this section, all categories of users have a big margin of choices depending on their needs and on their considered results. But most of these tools require good technical knowledge, programming skills and the interaction of several actors, for the pedagogical tools used by the instructors allowing the generation of serious games, are limited in one game genre "adventure video games", that limits the scope of the fields that will be concerned by these tools, for example there are some fields that are more adapted with the RTS or Platformer game genre, and give good results with this kind of genres more than adventure game genre, for this reason it's preferable to give to the users more possibilities to use other game genres in order to create more serious games. In addition, for all the platforms cited above there is a lack of the guidance system that will guide users during their game creation process, to ensure that the created or the generated games will be balanced on the level of the two aspects pedagogical and entertaining.

2.5 Serious Games application areas : A Survey

2.5.1 Introduction

The serious game is a specific type of game whose primary purpose goes beyond pure entertainment by teaching knowledge or training skills [77, 78], with the idea to apply learnt lessons in real-life work environment. A huge advantage of serious game compared to conventional forms of education is to foster high intrinsic motivation and positive emotional experience [79, 40]. These games are capable of simulating the general disorder of real emergency management room and they offer various possibilities of coaching with regard to the training of soft skills and communication behaviours [80]. Serious games are present in many areas of knowledge including military, health, manufacturing, education, economy and medicine. In this section we will present application o serious games concerning some fields, including health care and business, with a detailed analysis and description concerning each field.

2.5.2 Serious games in healthcare field

Healthcare has been among the first fields, which has experimented the integration of serious games in the learning process, several games have been developed or adapted to address several issues related to the presentation of some diseases, simulation of operations dedicated for the young doctors, exercise and rehabilitation for disabled patients, and any scenario happening in an emergency room, Therapy of cancer, diabetes, asthma, burns, and brain injuries , patients management in different clinical situations. It's been thirty years since the appearance of the first video games applied in healthcare especially in therapeutic purposes in different patient populations [81, 84]. Since the eighteen several serious games applied in different areas of healthcare field have been developed below, there is a description of some serious games ranked by application area in healthcare field.

First aid

Clinispace, in [85], and shown in Figure 2-19 is a 3D web-based application; it offers many scenarios and typologies of emergency patients. This game has been based on a previous study wherein is mentioned that the users need more accessibility and ease of use of the game. The Clinical space environments include clinical spaces such as an examination room, urgent care, a ward, intensive care and emergency bays, as well as support spaces such as a conference room and a reception area. A rich set of interactive objects are available to the learner including several medical instruments. The application can be accessible through a browser that will allow several learners to any-time anywhere access to these learning environments.

Figure 2-19: Clinispace Serious game.

The research team Virtual Heroes with the collaboration of Duke University Medical Center has developed 3DiTeams [86], shown Figure 2-20, it's a multi-player training video game, it's first person game genre, where the learner is placed in a high-fidelity virtual hospital. This game is based on DoD Patient Safety Program and Agency for Healthcare Research and Quality's Team STEPPS curriculum. The game consists of two levels, in the first one the learner is introduced to teamwork and communication skills. In the second one he applies these skills on several virtual scenarios. During the game each learner has a specific role as Doctor, nurse, technician, or observer. As a final step, the learners can generate a video playback of the scenario to observe and reflect on their own behaviours as well as those of these team-mates.

Figure 2-20: 3DiTeams serious game.

Burn Center, in [87], is a web based serious game developed with Action Script 3 "Macromedia Flash", it's composed of two parts, In the sorting part the learner should correctly stabilize, sort, tag, and transport burn victims during a mass casualty event in a busy theme park. In the second part the player has to use familiar computer-simulated hospital devices, it should satisfy the clinical needs of multiple burnt patients through a 36-hour resuscitation period. The game is equipped by an assessment system based on both time and score thanks to the assessment mechanisms; the evaluation of the game showed a positive correlation between the proposed game and learner performance in a traditional lectured course.

Dietitian and diabetes

Packy and Marlon [20] shown in Figure 2-21 is a platformer serious game for health dedicated for the children that suffer from diabetes, the game is developed by WaveQuest and published by Raya Systems for the Super Nintendo Entertainment System. It was designed to improve self-care behaviour in children with diabetes. The main characters in the game are two elephants that are at a diabetes summer camp. The gameplay of the proposed video game is centered on the two elephants that will retrieve the stolen goods, clearing out the malicious rodents, while also remembering to take their insulin and check their blood glucose. This game was evaluated in a randomized trial in which participants in the treatment group played the game for 6 months, in [88]. The result of the study has shown that patients who had access to the game showed a good progression concerning the self-efficacy for diabetes self-

[20] http://en.wikipedia.org/wiki/Packy_and_Marlon

management, increased communication with parents about diabetes, and improved daily diabetes self-management behaviours.

Figure 2-21: Packy and Marlon serious game.

Squires Quest! II, in [89], and shown in Figure 2-22 is a serious game dedicated for elementary children to increase their consumption of fruit and vegetables. The game is composed of 10-episode video game. The main objective of this game is to increase the adaptability of the young children to change their nutritional behaviours by consuming more fruits, vegetables and juices during the game progression, which should decrease risk of both obesity and certain cancers in a vulnerable segment of the population. The novelty in this game is that the parents of the learners can receive mail to follow the progression of their children, which will be beneficial for both learners and parents.

Figure 2-22: Squires Quest! II serious game.

Surgery

De Paolis, in [90], has created a serious game in 2011 for training surgeons on laparoscopic surgery suturing. The developed game was based on simulation and the

manipulation of the surgical instruments. The software architecture of the serious game has been developed using the model-view-controller (MVC) architectural pattern.

The research team of Cowan et al has developed in 2011 a serious game for off-pump coronary artery bypass grafting, cardiac surgical procedure (OPCAB) training [91]. The learners will start the serious game viewing the scene in a first-person perspective. The first step of the scenario begins where the learner is placed in the operating room as cardiac surgeon. The game includes also the mechanisms of surgical cognitive education and training framework. The main objective of this video game is to offer a modular tool on which domain-specific surgical modules can be developed. Therefore all of these features will allow the adjustment of various simulation parameters such as levels of audio and visual fidelity, etc.

The TKA "Total knee arthroplasty", in [92], and shown in Figure 2-23 serious game is a tool that aids the students learning the procedure and to be used in conjunction. The main objective of this kind of game is that the learner must successfully complete the TKA procedure by focusing on all steps of the procedure. The scenario of this game begins in the operating room where the learner takes the role of the orthopedic surgeon according to the first-person perspective. The main avatar works with other non-player characters e.g. "assistants and nurses" in order that from one team work will do the surgery for the patient. When the procedure is completed, the learn is shown a score the completion time, steps selected out of order, and the percentage of correct multiple choice answers, etc.

Figure 2-23: Screenshot from TKA serious game.

Nursing

Since the 1980s the nurse instructors first became interested in gaming as a pedagogical tool [93, 94] and beyond the 1990s nursing education also appears to lack research on the use of gaming in education [94, 95]. Many nursing serious games have been developed by different academic organizations, computer sciences laboratories and also game editors; below we will present some gaming studies and projects in nursing education that have been realized this last decade.

In 2000 Jones et al, in [96], have tested the competency knowledge of staff nurses on a neuroscience intensive care unit regarding cranial nerves. The authors created the Cranial Nerve Wheel of Competencies game to test learning after these nurses participated in twelve cranial nerve lessons over a 12-month period Participants took pre-tests and post-tests during each month's training session. At the end of the year, two teams of five members each competed in the game as fun, non-threatening way to test learning on the twelve cranial nerves. Based on student evaluations, participants identified gaming as an exciting alternative to written exams. The study describes the variety of advantages to using gaming as an alternative teaching strategy.

The main objective of the study, in [97], realized by Cowen and Tesh in 2002 on the Effects of Gaming on Nursing Students' Knowledge of Paediatric Cardiovascular Dysfunction is to determine if a combined lecture-game approach was more effective than lecture alone in enhancing student learning on pediatric cardiovascular dysfunction content. The study supported the use of gaming as an effective tool for knowledge retention. While Cowen and Tesh reported pre-test scores that showed no significant differences, they also reported students in the treatment group who answered 94% of the post-test questions correctly versus only 85% for the control group. This difference in test scores indicated that gaming enhances learning and retention of knowledge and student evaluations indicated that the games made learning interesting and fun.

After one year in 2003 Metcalf and Yankou, in [98], published a new article Using Gaming to Help nursing students Understand Ethics. The game was based on

ethical dilemma case scenarios where two students present opposing sides on what should be done to resolve a specific ethical dilemma. Each student was required to define the problem from their own perspective, consider their own values and how they might pertain to the dilemma, identify their professional responsibilities to the people in the scenario, consider principles such as autonomy and justice, determine legal requirements and social expectations identify alternatives to the dilemma, and identify potential consequences of those alternatives. Among the benefits of the game according to the authors : an increased self-confidence surrounding the identification and resolution of ethical dilemmas; an increased acceptance of others; a decreased level of judgmental attitudes; a higher stimulated interest in the topic, and a fun approach to increased knowledge.

In the same year another article by Kerr and Buttercase, in [99], titled Its Your Move, spoke of playing a game modelled after monopoly to increase staff awareness on clinical governance. The main objective of the game was to ensure that staff members were educated on the importance of clinical governance and its importance in daily work life. The intent was to provide an informal and fun atmosphere where staff members were given the opportunity to discuss situations, make decisions on appropriate action to remedy those situations, and identify the requirements they needed to meet and to deal with those situations. The game enhanced knowledge on the bigger picture of clinical governance situations. Informal participant comments indicated the game was fun and provided a relaxed atmosphere for learning.

In 2007 Frazer, in [100], completed her doctoral dissertation about The Effect of Gaming as an Instructional Strategy on Baccalaureate Nursing Students Immediate Knowledge and Knowledge Retention. The purpose of the study was to compare combining lecture with discussion versus lecture with a game concerning each combination's effectiveness on both immediate knowledge and retention of knowledge, and also to determine student attitudes on gaming.

Royce and Newton, in [101], published an article titled How Gaming is used as an Innovative Strategy for Nursing Education. This informative piece discusses the advantages and disadvantages of gaming, summarizes four studies involving gaming

as an innovative teaching strategy, discusses the need for research and testing, and provides implications for nursing education.

Finally, in 2012 Alawar Entertainment developed a game called "Hospital Haste" which is available on PC and in the iTunes store. In Hospital Haste the player must direct a nurse in diagnosis, treatment, and curing her patients. Time management is used to direct the nurse according to patients require priority, in order to send all patients home healthy [102]. Merscom, the developer of "Hospital Hustle", went a little further in that the player must manage the ward as well as a nurse. Placement of treatment devices and beds is as much a priority as directing the nurse to diagnose and treat patients. Adaptation of such a game could be made to suit specific and modelled needs of a real life hospital and style of ward.

2.5.3 Serious games in business field

Focusing on the field of economy, the use of serious games can provide an additional mean to increase interest in training, coaching and evaluation of user performance. For instance, serious games are conceived to carry out simulation for strategic decision support for a project or a company. Applying serious games to the economics field can help to solve several issues that most of traditional ways of learning are facing. Games can project the player into a real situation that changes according to his choices; this interactivity allows them to live an unforgettable experience full of instructive messages and information. According to a study [82], the Business game, hosted on Disney.com, receives 294.934 unique visitors/month even though it is buried deep within the Disney site.

A lot of organizations such IBM, Cisco, Renault and Deloitte are increasingly using serious games to train their employees in several fields ranging from compliance to leadership. New employees are not very engaged and motivated by traditional ways of learning. This is a huge problem for most fields especially economy, business and finance, because serious games are attractive and more engaging, and thus companies have found that the application of this new approach for training is helping them to improve employee's performances. In this part of this article we will present the art

of state of some serious games applied in finance/business training, marketing and sales.

Business training

Deloitte Business Simulation game, in [83], and shown in Figure 2-24, is designed to train employees in corporate responsibility and sustainability. The game enables players to experiment with a realistic model of their company and its potential future scenarios. During the game, the players go through various scenarios and are confronted with the consequences of their decisions just as in the real world. This hands-on experiential learning helps to sharpen management skills through practice and feedback.

Figure 2-24: Deloitte Business Simulation game.

Coco Sim[21] shown in Figure 2-25, is a simple business simulation that teaches the lean approach, the game has been developed by Front Square; the objective of the game is to manage a chocolate store by managing the cash flow and stock levels in order to achieve a high customer satisfaction level while also remaining profitable. Player's skills are tested with regular questions and the combined game and question scores are then posted on a leader board to help drive competition and engagement. Line managers and HR managers have access to the learning analytics to see who is doing well and who needs performance intervention.

[21] http://www.frontsquare.com/story.html

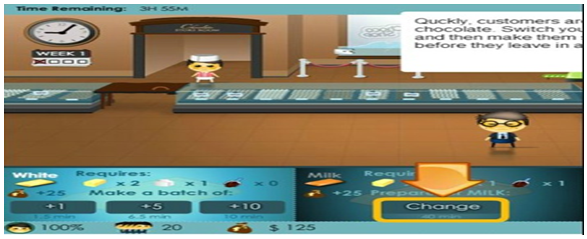

Figure 2-25: Front Squares CoCo Sim.

Finance training

The true office[22] shown in Figure 2-26, is a serious game for objective to deliver engaging compliance training. True Office enables employees to explore scenarios such as anti-money laundering and insider trading through interactive gameplay and immersion. True Office also provides a variety of games that can be tailored to match each company's own internal policies through customizable narratives.

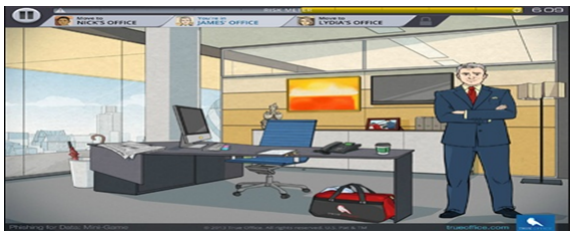

Figure 2-26: The True Office serious game.

conomia[23] shown in Figure 2-27, is a serious game based on the monetary policies of the European Central Bank to teach employees about the impact of interest rate changes on unemployment, production growth, inflation, and other vital economic indicators.

[22]http://www.trueoffice.com
[23]http://www.ecb.europa.eu/ecb/educational/economia/html/index.en.html

Figure 2-27: conomia serious game.

Marketing and sales training

IBMs CityOne[24] shown in Figure 2-28, is a serious game which aims to influence the behaviour of the employees, business partners, clients and future clients. As a marketing tool, the game enables companies like IBM to market its products and services in a way that engages existing customers and potential customers more deeply, making the company's value proposition clearer and more compelling.

Figure 2-28: IBMs CityOne.

Business teaching

In light of entrepreneurship, the students are the major target of the project. Good serious games challenge emerging to foster the Business courses, in order to develop, deploy and assess experimental pedagogical plans based on appealing and instructive for simulating entrepreneurship [103]. In Venture Strategy simulation, presented in Figure 2-29, students start a new company that enters the microcomputer industry. They deal with Marketing, Product Development, Accounting, Finance and Manufacturing Fundamentals, Financial Analysis, Business Partner Negotiations, Human

[24]http://www.01.ibm.com/software/solutions/soa/innov8/cityone/index.jsp

Resource Management and e-Commerce. As the executive team, students are provided the seed capital (investment money) to start their business. They can use this money to build a factory, open sales offices and/or a web site, and design brands. They invest 2 million in the first quarter and another 1 million in each of the next two quarters. An additional 4 million becomes available in quarter 4 from venture capitalists, for a total of 8 million. The executive team has a year and a half (6 quarters or decision periods) to get their company off the ground. Within this time frame, they should become a self-sufficient firm, earning substantial profits from their operations. The students can play against their peers or against computer-generated competitors. The play against computer version allows everyone to work at his or her own pace and there is no need to coordinate the play of all of the students.

Figure 2-29: Venture Strategy serious game.

Social Security

Working at height training is the serious games developed by Serious Factory[25], Figure 2-30. This game serves as a safety training tool for construction workers. The game is divided into two parts. In the first part, the player needs to identify seven working-at-height hazards in a construction site and select the necessary safety precautionary measures for each of the hazards. In the second part, the player is required to erect a metal scaffold according to a safe working sequence. The player will also be asked some questions about various requirements of a properly erected metal scaffold.

[25]http://www.seriousfactory.com

Figure 2-30: Serious factory's working at height training.

Our classifications are based on three related subjects: Serious game, Business and player. Focusing on serious game subjects, we can classify by game functionality. For business subject, we can classify by application area and game objectives. Finally, focusing on player subject, two types of players can be considered (professional/non professional), and both are included into the same classification.

Classification by game functionality

According to [103], we identified some criteria for classification of serious game for health. We build upon their criteria (application area, interaction technology, and game interface, number of players, game genre, game engine and platform) and we add some characteristics (assessment, game objective).

The descriptions of our classification are based on:

- Game objective, which describe the part of real world being modelled by software. In the serious game for business field, we will distinguish the main aspect: management, recruitment, communication and marketing, business teaching and social security.

- Interaction technology has the different paradigms for establishing communication between humans and computers. Both hardware and software are included.

- Game interface is related to the virtual world inside the game which can simulate the real world in three dimensions (3D) or simpler world environment in two dimensions (2D).

- Number of players using the world of the game.
- Game engine is a system designed for the creation and development of the game. The engine provides an API to access lower level functionalities and a set of predefined models, materials and scenes [104].
- Platform means the hardware that the application runs on.
- Assessment, is the evaluation of the player's achievement on parties of the game. it offers an important benefit for the player by giving him information about development career, recruitment or management. Exploring his personality, potential, values and intellectual abilities, it can draw a detailed profile of the individual as well as its proven strengths and needs of potential development.
- Age range can be defined as the age group where objective of the game is oriented to that generation.
- Game genre is a category related to the game play; we can distinguish strategy, adventure, quiz, simulation, among others.

The information collected from A.1 has been used to compare the characteristics of the surveyed serious games with respect to different parameters shown in the Figure 2-31.

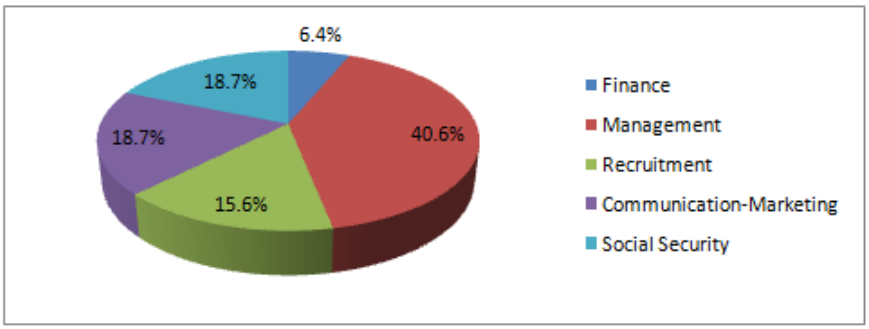

Figure 2-31: Breakdown of the Game objective values present in our survey.

Focusing on the domain of the developed serious games, we can see that their applications are quite varied between Finance, Management, Recruitment, Communication-

Marketing, and Social Security. An emphasis can be clearly seen on Management area by 40.6%.

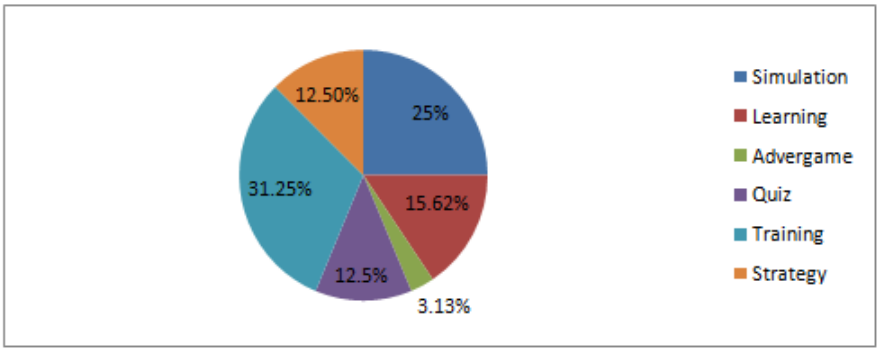

Figure 2-32: Breakdown of the Game Genre values present in our survey.

The chart shown in Figure 2-32, presents the distribution of serious games according to the genre for which they have been designed: Simulation, Learning, Advergame, Quiz, Training, and Strategy. We notice that most of Serious Games are made for simulation and training Business.

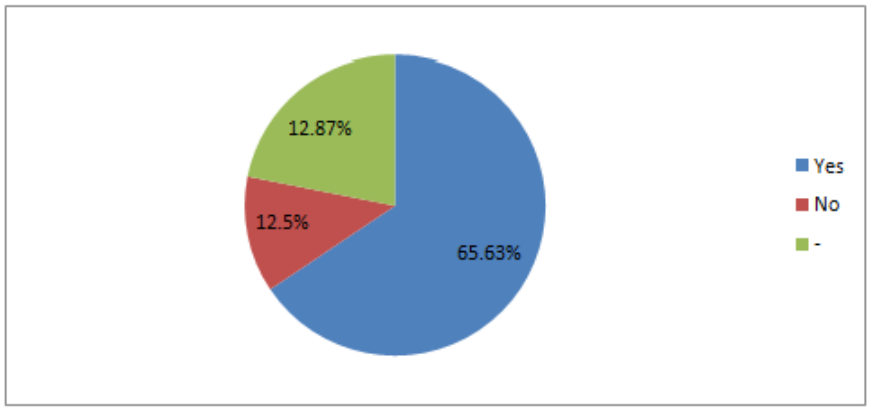

Figure 2-33: Breakdown of the Assessments values present in our survey.

This chart in the Figure 2-33, shows the variety of the application assessment in serious games for Business to improve player skills. We can see that 65,6% of serious games implement an assessment system.

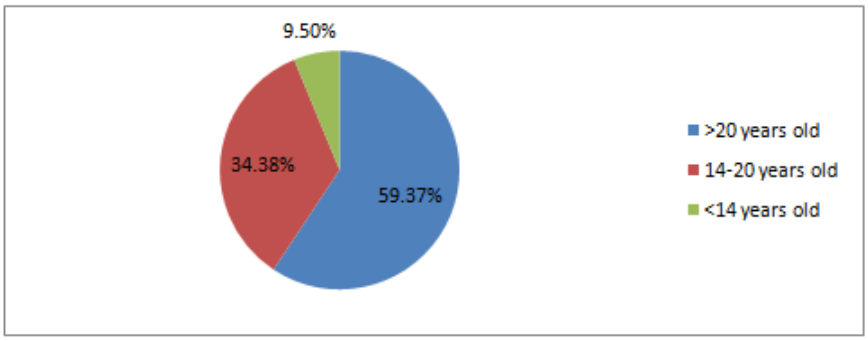

Figure 2-34: Breakdown of the Age Range values present in our survey.

Focusing to the target of players of serious games in Business, Our studies are defined on the age players, shown in Figure 2-34, we notice that their application is designed with a quite variety of the people who have an age higher than 20 years (59,37%), it presents the targeted field and required a specific knowledge that is achieved with study and experience. Despite the small percentage that represents the business serious games dedicated for children, we notice an important emergence of serious games for kids. due to the intrinsic interest that serious games can provide on teaching business they apply learnt lessons in real-life environment related to business since their young age.

2.5.4 Conclusion

The technological progress that video games industry knows and especially serious games can be beneficial for education and learning process even for children. These points of benefit have created the need to create a variety of serious games concerning several fields. With the variety of the projects realized since the 80's, the development of the new serious game requires the new innovative ideas, new methodology of design easy for the designer and that takes into consideration the educational aspect since the beginning of the design process, and also the latest technologies that allow the creation of games in different platforms particularly on the web. The instructors and the designers have to create innovative games concerning the new fields or that resolve the new issues.

Chapter 3

Contributions and Productions

3.1 Adaptation of rapid prototyping model for serious games development

Serious games are a very effective and highly interactive instruction tool. When combined with lecture-based training, they can increase participant interest and make the training process more enjoyable, memorable and effective. To create such a game, we need a design process that combines both educational and entertaining aspects, and also allows saving cost and time of development.

3.1.1 Introduction

The transfer of knowledge from the teacher to the learners requires the use of different types of mass media, which are intended to reach a wide audience through the mass communication. Among the media that have known a big success this last decade and are increasingly used in education, there are video games. The strong points of video games are the influence and targeting of the large margin of young people, this is due to their interactive environment and the unforgettable experience that they can offer to the players. The video games that have the educational purpose are known as serious games, such games can combine both educational and entertaining aspects to create the desire into the learner to play and learn during the game progression.

The education can benefit from using serious games because they are an increasing popular and important part of the entertainment industry. The industry estimates range from $2 to $10 billion in revenue for the serious games space, depending on how much of the market is for games, simulations and virtual worlds are included in the calculation [105]. Unfortunately the design process of serious games is a complex task; it needs a lot of resources, time, and money. Each phase of the process requires the intervention of experienced actors, and in addition, there is no specific protocol that has yet been developed resulting in the use of methods designed for video games or educational systems that are patched up in an effort to adapt them to the needs of serious games [106]. For these reasons we propose in this section a design methodology of serious games based on the rapid prototyping model, in [107, 108, 109], often used in instructional design, this methodology will help game designers especially the beginners to create their own serious games easily.

3.1.2 Related work

The process of game creation has known the coming into existence of several design methods dedicated to create different serious games, these methods have been used in both game industry field and education field. The team of the learning game factory [106] has proposed a model related to the process of the serious game design that begins with the specification of the pedagogical objectives "pedagogical content" with the cognitive experts and the domain experts, then the pedagogical expert designs the serious game, the operation will be detailed through several documents. The team has developed a technical tool dedicated to support the model; the tool is composed of widgets to formalize an aspect of Serious Games, and also to create the serious game scenario according to the IMS Learning Design formalism. The company KTM Advance specialized in the establishment of the video games creates also a model for the design of serious games [64]. The KTM Advance model consists of five complimented steps in order to create serious games, the model begins with a step called needs analysis [A], in this step the designer defines the technical and pedagogical features of the Serious Games. They use the concept note summarizing

the educational needs of the customer, in order to define the pedagogical content. Afterwards an analysis of the content is done, and the different elements of the content are grouped in a hierarchical list. These elements grouped in this step will be used in the proposition of the game design step [B]; during this step the designer invents the games' mechanisms to transmit the content, this proposition is detailed in different aspects e.g. "scenario, gameplay, etc.", in a specific document. After the game design step come the prototype development step [C], in this step the programmers create a prototype of the game. The prototype created can test the relevance of the proposed mechanisms related to the pedagogical objectives defined in the first step. The game is developed according to an iterative process in the iterative deliveries step [D], in this step the customer sends a list of modifications, after the test that he has made on the submitted game. As a final step called final delivery [E] the users test the game to ensure the relevance to the envisaged objectives. The three universities of the Netherlands have created an the EMERGO methodology, in [68] that concerns the creation of serious games for the higher education, the type of the game created according to this model is investigative where the player has to solve a problem. The methodology is composed of five steps, these steps are done iteratively. The first step in the methodology is the case idea; during this step the instructors must define their pedagogical objectives and the context of the use of their serious games. After this step, comes the scenario design step where the instructors must describe each scenario, in a scenario there are three levels of description, global scenario description, a detailed scenario description and the specification of each screen e.g. "editor QCM, chat tool, taking notes, etc.". In the development step the development team creates the serious game then it will be tested by the users to remove all programming errors. The final step of the methodology is evaluation; during this step, the instructor returns to its list of educational objectives defined at the beginning of the project and verifies whether the LG responds well. The company Paraschool has proposed another industrial model for the design of serious games for educational purposes [66], This model is composed of three main steps; the first step of the proposed model refers to the preliminary work of the designer: to determine

the objective of the project, identification of pedagogical objectives, etc. As a second step, there is the general design, during this step the designer has to develop the important points concerning the principle of the game for transmitting educational content, among these points there are the video game genre, the game world, the objective of the video game, characters. In the detailed design step, the designer creates all the games rules, graphical interfaces, gameplay, and game mechanics, etc. This step results in the creation of a complete video game that meets the objective envisaged by the designers. The created serious game by using this method will be tested in intern, until the validation of the final consumer. This model of Preschool Company illustrates the influence of computer engineering methods and especially the cascade model on the design of Serious Games.

The design of both serious games and video games requires a design process with clear and detailed steps, several approaches and methodologies mentioned in this part have been created by different institutions and companies specialized in the video game industries, which causes that each approach has its own characteristics, most of these methods have one thing in common which is that they are based on iterative process, where each step has a particular task with the aim to create the envisaged video game. Until today there is no standard that unifies the deign process of serious games, that causes the problem of which is the best method that will allow the gain of the time and cost of creation, also we notice that most of these methods require the collaboration of several actors, in addition there is no method dedicated for the beginners for example the students who want to learn how to create their own video games. For this reason we aim to create a new design methodology dedicated for this kind of users.

3.1.3 The proposal

After several researches to find a game design process with clear steps and that allows saving cost and time of creation, we have found the rapid prototyping model, a model dedicated for instructional design, one of the most powerful points of this model is that it's centred on the creation of a prototype, that will be improved according to the

process iterations; therefore, in the earlier stage of methodology the game creators can have a prototype that will be both tested and improved. Our research team has modified it to be adapted to design serious games; the proposed design model is composed of five major phases "Need analysis, Design, Prototype and Development, Validation and Evaluation" represented in 3-1.

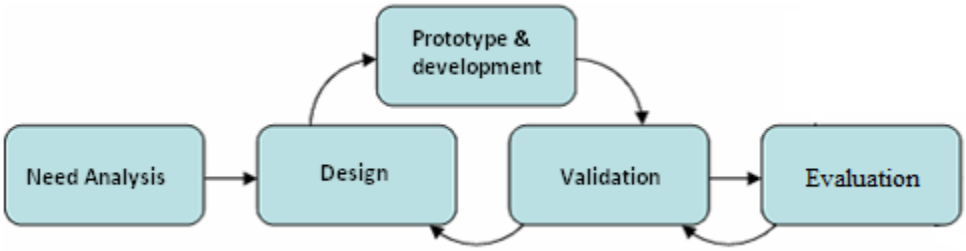

Figure 3-1: The Design Methodology for the Serious Games.

Need Analysis

During this phase the game designer has to describe the need that leads to the creation of the video game, and define the set of pedagogical objectives that the learner must acquire when he completes all levels of the game. Description of need: The description of need is a general description of the serious game that will be developed; it includes features, general objectives and skills that the learner must acquire during the sequence of the serious game. Pedagogical objectives: The pedagogical objectives are statements of intent teaching, they are intended to describe the outcomes of the serious game. In general, the pedagogical objectives are extracted from the description of need and through different questions posed to the domain experts, those objectives describe the aim, skills, and expected results that will be acquired during the game progression.

Design

Design is the phase where the two aspects educational and entertaining will be combined to create a serious game that attracts the attention of the learner to play more, and learn as he plays. This phase is composed of different steps: Developing the game

story, Establishment of flowchart of scenario, Characters description and Levels description. Developing the game story; the game story is the art of presenting a story in a compact and intriguing manner to create a desire to the player to play more. In this step the game designer can imagine different chronological events that happen to the main character to achieve the objective of the story, in order to attract the attention of the player, the game designer should introduce the same techniques that attract the learners attention e.g."challenges, puzzles, suspense, etc.". Establishment of flowchart of scenario: The scenario can be established by using a flowchart [110] in order to have a clear and global view of the story, for this reason we present in this section an easy flowchart of scenario shown in Figure 3-2 composed of three different components "Non Play, Mission and Immersion", each component of the flowchart has a specific role described below: Non Play: This component describes an animation or a video introduction to begin or introduce the mission or the immersion. Mission: It's the main component, where the player does different tasks and avoids obstacles to achieve the pedagogical objective of the mission; this component is composed of five sub-parts described below:

- Objective: In this part the designer defines the main goal of the mission that will be achieved by the hero or the protagonist of the story. Obstacles: in this part the designer describes the different things, objects or events that prevent the hero from achieving the main objective of the mission e.g. "enemies, traps, etc.".

- Rules: In general, the rule is a relationship between actions "verbs" and challenges.

- Rewards: Description of recompense given to the hero if he achieved the objective of the mission or the immersion e.g. "win the points, win coins, etc.".

- Punishments: Description of the penalty that will the player undergo if he didn't achieve the objective of the mission or the immersion e.g. "loss of the points, etc.".

- Immersion: This component is the same as a mission, but with entertaining objectives, the component is also composed of five sub-parts “Objectives, Obstacles, Rules, Rewards and Punishments”.

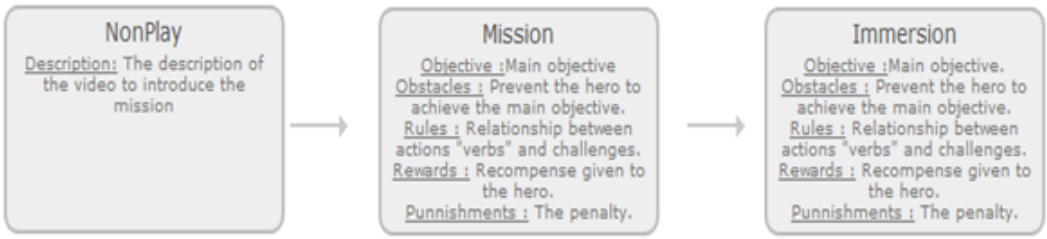

Figure 3-2: The Flowchart of the Scenario.

Characters description: The characters that have been described in the game story will be detailed in this section through the 3.9; in general, there are three kinds of characters exploited in most games. Main character: the main character is the protagonist or the hero of the game story. Non playable character: the non play character or non-person character is any character not controlled by a player. In electronic games, this usually means a character controlled by the computer through artificial intelligence. Enemies: the enemies are the characters who try to prevent the hero or the main character from achieving his objectives. In general each game can have one or different kind of enemies controlled through artificial intelligence.

Table 3.1: Character description

Age	26
Height	170cm
Race/Nationality	American
Job Title	Soldier
Abilities	Has the ability to Double Jump.
Purpose	Destroy the enemy .

Levels description: most of a video games have one or more levels, during this step the game designer has to develop the map associated in each level of the video game or each specific area that belong to the level; in addition, he has to define the gameplay [67], the dialogue, and the technical details that belongs to each level by drawing a map with a legend presented in Figure 3-3, the level represents the places of different components of level like "start point, Check points, Pick-ups System, Objects System, etc." and also the flow of path game progress.

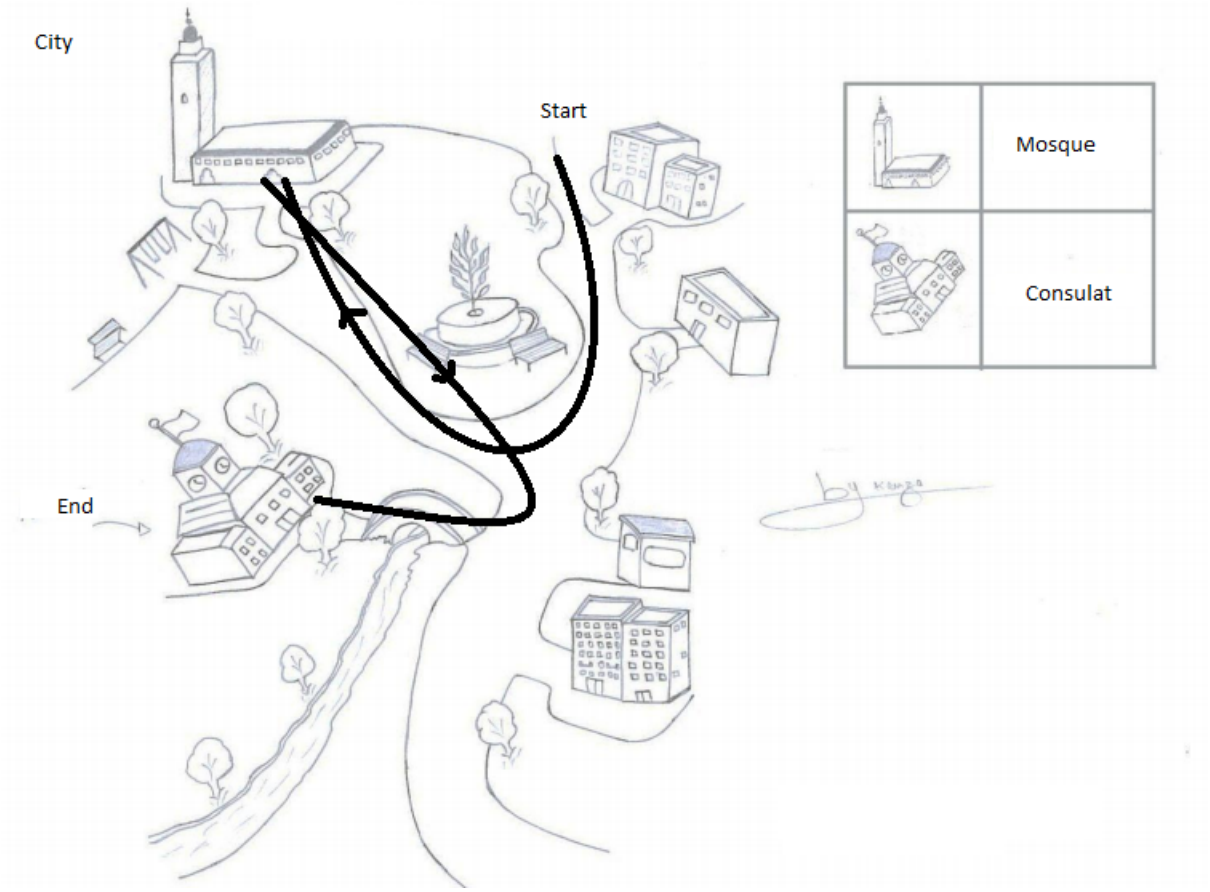

Figure 3-3: Map of the level with a Legend.

Prototype and Development

In order to create a prototype of the serious game, we conducted several studies about methods and technologies of making games, and then we ended up with some requirements that our game should respect. In fact the tools and the game engine

should be:

- Cross platform.
- Scalable/Extensible.

Among the game engines that we have used for the development of different video games to test the proposed model, there are libgdx[1] and cooperlicht[2]. The two game engines are free, open source and cross platform. In this phase the game programmers can start working on the specification and conception using UML[3] in order to construct the basic layer that uses the basic functionalities of game engine see the Figure 3-4, this layer will make use of all the coming development.

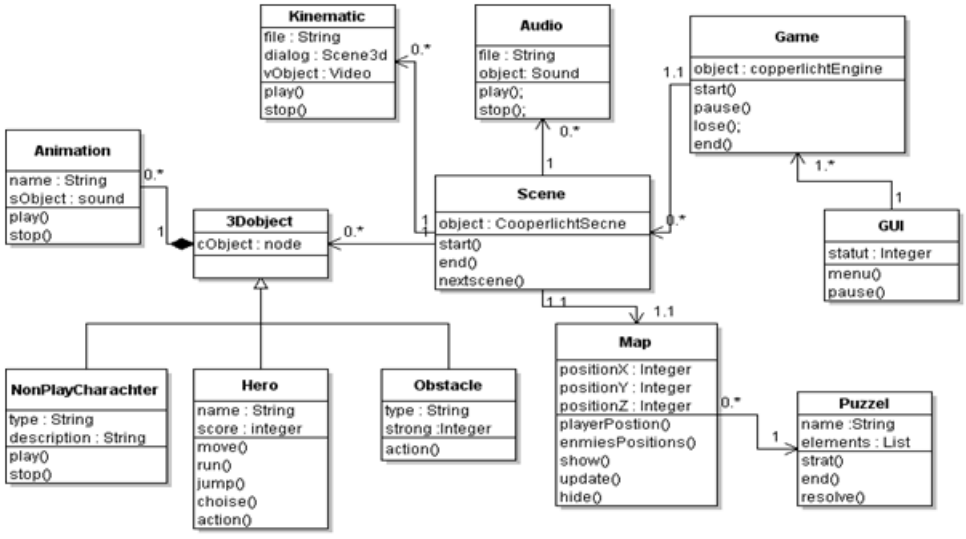

Figure 3-4: UML Class Diagram of Game Objects.

Validation

The validation phase begins when the development of the first prototype has been done, during this phase the game designer has to verify if all the pedagogical objectives mentioned in the need analysis phase, were implemented in the game in a proper way. The verification can be done by using a check-list of all pedagogical objectives

[1]http://libgdx.badlogicgames.com
[2]http://ambiera.com/copperlicht
[3]http://www.uml.com

mentioned before, see Table 3.2. The advantage of the prototyping is that the users don't have to imagine what those specifications really mean in term of working system. They can actually experience them, and thus find the problems or enhancements that they may not have considered otherwise and also verify if the pedagogical objectives were respected. This phase plays an important role in design process because it saves time and cost of process; because the pedagogical objectives will be validated before the development phase. In addition, during this phase several tests should be done by the game designer or by the test team to find 'bugs' in the programming code or graphic layers.

Table 3.2: Cheek-list of pedagogical objectives

Pedagogical objective	Status	Description
Pedagogical objective 1	OK	-
Pedagogical objective 2	KO	-

Evaluation

The phase of evaluating is the final phase in the proposed model, in this phase game designer and the end developers will evaluate, continue the tests that were begun in the validation phase and confirm the final version of serious game developed by the development team. Among the criteria that have to be evaluated during this phase there are Reliability, Portability, Efficiency, and Maintainability. Accessing reliability, efficiency, and maintainability requires the check of at least the following software engineering best practices and technical attributes:

- For reliability, there are Coding Practices, Complexity of algorithms, etc.
- For the performance efficiency, there are Memory, network and disk space management, Coding Practices, etc.
- For the maintainability, there are Code readability, coupling ratio, Coupling ratio, Documentation, etc.

3.1.4 Results

By following the design process proposed in this study, we have succeed in creating some serious games "Figure 3-5, Figure 3-6 and Figure 3-7" related to different fields like religion, nursing training and humanitarian immunology. In general, the feedback of the learners who have used these video games was positive, and they have learned and in the same time enjoyed the experience.

Figure 3-5: Screen-shot of Serious Game that Teaches Islamic Prayer.

Figure 3-6: Screen-shot of serious game that teaches immunological technique.

Figure 3-7: Screen-shot of serious game for nursing education.

As an example the video game that teaches Islamic Prayer was tested by 60 learners, including 20 children, 30 bachelor students and 10 master students, the statistical study, see the Figure 3-8, was about learner satisfaction.

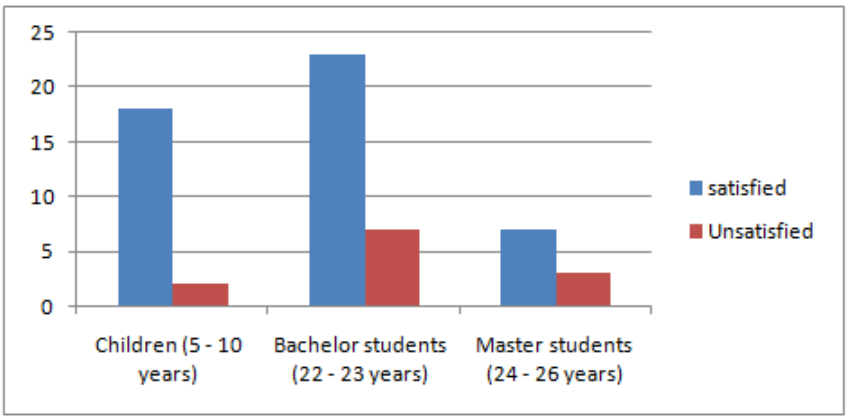

Figure 3-8: Graph Presentation of Learners Satisfaction.

3.1.5 Conclusion

To conclude, the proposed design model has proved successful by creating different video games in different fields, this methodology has fixed the majority of the issues met during the creation of serious games. Among the fixed issues there is complexity

of the design process, the different phases of the proposed design methodology are clear, easy to establish and do not need the interaction of several experimented actors. Among the perspectives considered, there is the development of a game generator dedicated for the non-experts "Instructors and Trainers" that allows the generation of different serious games without the interaction of game programmers nor the artistic team.

3.2 Towards a new web-based serious games generator based on fuzzy expert system

With the big success that serious games have known in the education field, a huge need has been created to develop such video games in order to satisfy the demand that does not cease to increase, but the time, the cost, and the interaction of several actors during the creation process of video games can influence the envisaged result and create several unexpected problems. To avoid such problems we propose in this article a new web-based serious games generator that adapts the process of video game development by replacing game design and game development phases by both programmed game design and gameplays, this new concept will allow the game creators to focus more on pedagogical aspects and pedagogical objectives that the players must acquire during a video game sequence, instead of wasting much time in game design and game development. In addition, the proposed game generator will be equipped with a fuzzy expert system to assist the users during the game generation process; the proposed serious games generator will be able to generate several web based video games that are both educational and fun.

3.2.1 Introduction

The creation of serious games requires the collaboration of several experimented actors; in most cases the big part is done by the development team which ensures the integration of resources and mechanisms envisaged in the video game, the programming part and technological choices can prove decisive, often the programming part is not done entirely, there are several tools for creating video games or source code reused; sometimes it's possible to change the existing to achieve the intended result. Among the tools used in video game creation there are game engines which are designed to create a simple video game. The core functionality typically provided by a game engine includes a rendering engine which supports 2D or 3D graphics, a physics engine with collision detection, sound, scripting, animation, artificial intelli-

gence, networking, streaming, memory management, threading, localization support, and a scene graph [111].

The combination of the game engine, with the preprogrammed gameplay, and the several APIs, provides a platform called game generator, the main role of this platform is the generation of video games according to the need of the users. In general, the game generator is dedicated for the non-experts in the video games creation field; it allows them to create different video games in an easy way without the interaction of the game designer, the development team nor the artistic team. Among the main objectives of this new concept is saving the time and the cost of the game creation process. In this perspective of research and development we aim to develop a serious game generator equipped with a fuzzy expert system that guides and gives the indications to the users during the game generation process. The proposed game generator will be able to generate several web-based serious games according to the chosen game genre. In this way, making serious games won't require any-more learning, neither programming languages, nor the implication of game programmers.

3.2.2 Related work

The serious game generator requires more than a normal game engine; it must be able to generate video games that combine entertaining and pedagogical aspects, assess the ability of the players and more features that will help the learners/players to improve their skills in the targeted field. Many game engines, frameworks, game generators, platforms and tools dedicated for serious games, have been developed by different organizations, laboratories and universities these recent years. Among those solutions there is a framework for serious game-based learning design [73], created through mEducator project, the framework uses mEditor scenario editor that mixes visual programming and work-flow management, letting designers, model how the game should react to user input, the serious game editor offers the flexibility and the ability to the educators to create custom serious games to serve their learning objectives. LUDOCORE, in [74], is a logical game engine based on event calculus, allows linking game rules to the formal logic used by automated reasoning tools in artificial

intelligence. It serves as a bridge from the concerns of game design to logic-based Artificial intelligence tools; it has also served as the basis for implementing interactive prototypes. The TARGET platform, in [112], supports the TARGET Learning Process, consisting of multiple tools and services, which can be extended. The core service is the Virtual Business Environment, a serious game targeting the domains of project management and innovation. In the health care field there is Open Wonderland [113] a toolkit for building 3D virtual worlds, it's designed primarily for developers familiar with the Java programming language and allows to theme the creation of dynamic learning environments, collaborative business applications, or interactive, multi-user simulations. <e-adventure>, in [75], is a platform developed in Java programming language, based on a XML interpretation engine and a graphical user interface that allows the creation of the games graphically, dedicated to facilitate the creation of adventure serious games, realized as part of a research project of the "Complutense de Madrid University". the process of creation thought this platform begins when the user chooses a condition from a predefined list, then associates divers actions e.g. "add objects, change scene, or establish a conversation, etc." to the chosen condition. Concerning the conversations, they will be related to each character via a dedicated editor, each conversation is composed of several phrases. The video games created through this platform can be integrated into LMS via the Scorm standards.

All of the platforms mentioned above have as objective the creation of several serious games, but the problem is that most of them require a technical, programming, artistic, and conceptual skills, in addition, to logical reflection, the interaction of several actors, limited in the creation of one game genre, and there is a lack of a system that guides the user through the creation or generation process in order to create a video games that are both pedagogic and fun. In this research perspective, and according to the ideas extracted from the use of those different game engines, platforms and frameworks mentioned above, our research team aims to develop a new game generator that allows to the non-experts in the serious game industry to generate their own serious games according to their need. In order to facilitate the task for the users, the proposed game generator will be equipped with a fuzzy expert

system that notices and guides them to create their own video games without the intervention of any game designers or development team.

3.2.3 The Main Issue

The first actors in the process of serious game creation are the instructors and the experts in the field, the thing that leads to scenarios oriented content more than scenarios oriented game, then, this is the game designer that must seek a compromise between content and gameplay to create a game play that sticks to selected content and message, see the Figure 3-9.

Figure 3-9: The process of serious games creation.

However it is better to give a list of gameplays to the instructors or the experts in the field who can choose which will be the right mechanism for such content. With this second approach we eliminate the intermediate part between programmers and experts / instructors, see the Figure 3-10.

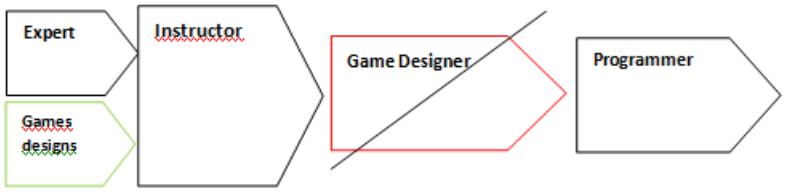

Figure 3-10: Process of serious games creation without game designer.

In the third approach we aim to eliminate from the process two profiles that are programmers and game designer, to make way for the experts and the instructors who can choose one of the mechanisms previously designed by the game designer and programmed by the programmers, see the Figure 3-11.

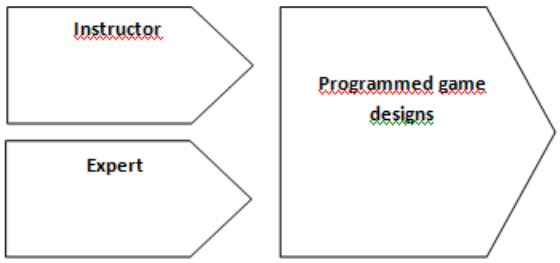

Figure 3-11: The process of serious games creation with programmed game designs.

This third approach will allow the instructor and expert to generate their own video games that meet their needs, by using the game generator based on the programmed game designs and gameplays; with this approach the game creator can spend more time to define the pedagogical objectives that will be transmitted to the learners during the sequence of the video game, the concept of the proposed game generator will be detailed in the next section.

3.2.4 The concept of the game generator

Based on the study [67], about gameplays classification, and that proposes the model G/P/S of classification, we can extract the basic gameplay bricks, with which we could create the most serious games. By linking the bricks each other we can include any kind of existing standard games, but bind, chain and attach the bricks cannot be done randomly, in addition linking and communicating between the bricks can be very contentious. In this section we will describe the concept of the proposed game generator, with the general rules that will be respected by the user to lead to the envisaged results.

The concept of proposed game generator

Before proceeding to the definition of unit blocks and the nature of the relationship, we must emphasize the big lines that made an educational game:

- Knowledge and educational messages

- Entertainment
- Evaluation

These three points are the basis of any serious game, see the Figure 3-12, where the educational message is the main objective, the entertainment allows the learner to hang in the game, the evolution of the player and whether he has succeeded has mastered the learning objective, it is necessary to set up a monitoring course and statistics.

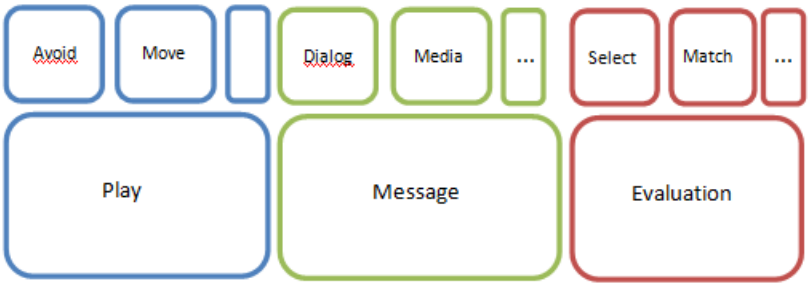

Figure 3-12: The architecture illustrating the three basic elements.

The proposed serious game generator is a platform that allows the creation of a cross platforms serious games; it will be dedicated to the non-experts e.g. "professors, instructors and trainers". The concept of the proposed game generator is based on different gameplay bricks; each gameplay brick has a specific role in the created video game, the main task of these bricks is summed up in the fact that they allow video games to be playable.

According to different studies of our research team, we have specified three types of gameplay bricks; this specification takes into account the nature of the gameplay brick, if it's educational or entertaining. We have in the first place the gameplay bricks for education able to transfer the knowledge to the learners, then the gameplay bricks for entertainment that have as a main role the attraction and the creation of desire into the players to play

gameplay bricks are neither educational nor entertaining, the gameplay bricks are categorized as below:

- Educational gameplay bricks: Create, Manage, Select, Write, and Message.
- Entertaining gameplay bricks: Avoid, Match, Destroy, Move, and shoot.
- Neutral gameplay bricks: Random, and media gameplay bricks.

This classification of gameplay bricks by three different types will be exploited by the fuzzy expert system.

The architecture of the serious game generator

The proposed serious game generator will generate web based serious games, therefore these kinds of games will need just a web browser to be executed. Concerning the architecture of such a system, as in the Figure 3-13 the generator is developed by using a combination of several technologies e.g. "java, JavaScript APIs, webGL, etc." and it's deployed in a server application. The instructor can establish scenario and levels of the game by using web interfaces where he can drag and drop several components in order to generate a serious game.

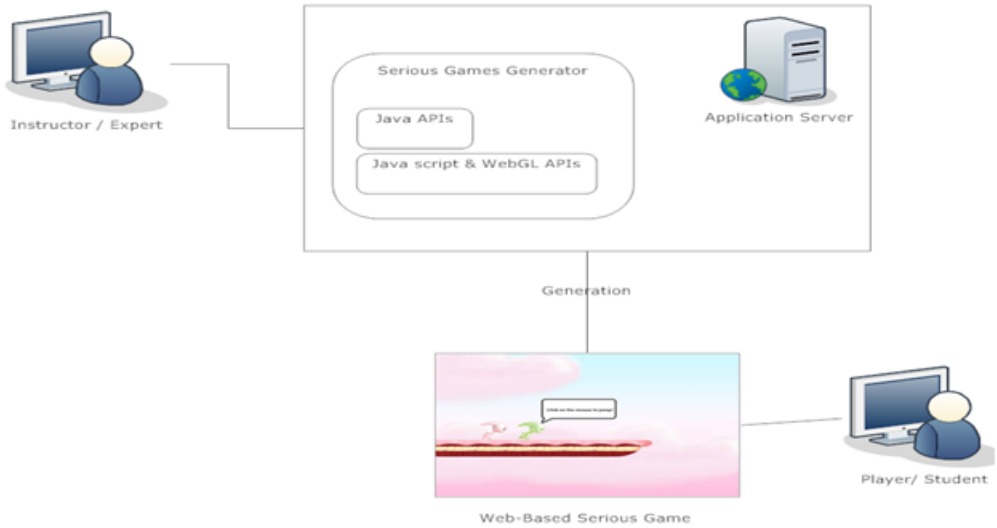

Figure 3-13: The Architecture of the Web-Based serious Game Generator.

The process of game generation

The process of the game generation, see the Figure 3-14, is composed of three principal steps "Game genre selection, scenario establishment based on gameplay bricks and levels establishment". In each step the user of the game generator has to do some manipulations in order to pass to the next step, until the generation of the serious game. An intermediate step, is added to the generation process, this step provides the validation for the transition from the step of the scenario establishment to the step of the level implementation, in this intermediate step the fuzzy expert system will control the percentage of each type of gameplay bricks, to provide the guidance to the user with the aim of generating a video game that is both fun and educational.

Figure 3-14: The Process of the game generation.

Game genre selection based on Analytic Hierarchical Process

Video games are often classified into genres, which purports to define games in terms of having a common style or a set of properties or characteristics, as defined in terms of perspective, gameplay, interaction, objectives. The typical genres include: Strategy, Action, FPS, Role-Playing (RPG), Fighting, Racing, Sports, Simulation, Family, Child, and Adventure in [114, 115]. Table A.2 shows a simplified overview of the six best known game genres.

However, current descriptors of video game genres are none standardized, undefined and embedded with multiple information [116]. Therefore, these problems can influence the outcome of the video games development process, and cause difficulties

in choosing the right game genre that will meet the need envisaged by video game creators.

Multi criteria decision methods: A survey : Multi-Criteria Decision Making (MCDM) is the study of methods and procedures by which the concerns about multiple conflicting criteria can be formally incorporated into the management planning process [117]. MCDM is a structured framework for analyzing decision problems characterized by complex multiple objectives [118]. The MCDM process typically defines objectives, chooses the criteria to measure the objectives, specifies alternatives, transforms the criterion scales into commensurable units, assigns weights to the criteria that reflect their relative importance, selects and applies a mathematical algorithm for ranking alternatives, and chooses an alternative [119, 120, 121, 122].

The analytic hierarchy process "AHP" is a multi-criteria decision making method "MCDM", it's also a powerful tool that may be used to make decisions when multiple and conflicting objectives/criteria are present, and both qualitative and quantitative aspects of a decision need to be considered [123]. The AHP provides the objective mathematics to process the inescapably subjective and personal preferences of an individual or a group in making a decision [124].The AHP method has been studied extensively and used in almost all the applications related to multiple criteria decision making (MCDM) in the last decade, several papers in multi criteria decision have used this method, 150 articles investigating the AHP concerning general applications in [125], 18 articles studying the AHP concerning finance simply [126].The AHP method was adopted in education, engineering, government, industry, management, manufacturing, personal, political, social, and sports [125].

Statistical study of video game genres : In order to feed the system of multi-criteria decision making based on AHP method, we have decided to hold a statistical study [4] concerning different on-line serious games according to their genre, we have filtered the results according to three main criteria "age, field and properties" and

[4] www.sglab.ma/list

for each main criterion there are sub criteria, for the age there are three intervals "3-10, 10 -18 and + 18", for the field there are also four sub criterion "education, economy, health care and environment," and for the properties there are nine sub criteria which refer to properties related to video games "Speed, Skills based, Intelligence, Precision, Reflection, Decision, Funny, Knowledge and Chance", Table 3.3 contains all percentages according to the genre and criteria mentioned above. These percentages will be used by the AHP method, to make decisions in order to select the game genre according to the parameters given by the users. The decision will help both game designers and game developers to select the best choice that meets the result that responds to the need.

Table 3.3: Statistical study on serious games according to the genre

-	**RTS**	**RPG**	**Simulation**	**Flash**	**Platformer**	**Puzzle**	**Adventure**
Age 3 - 10	40%	28.57%	7.14%	92.31%	80%	81.82%	100%
Age 10 - 18	50%	57,14%	50%	3,85%	20%	9,09%	0%
Age + 18	10%	14,29%	42,86%	3,85%	0%	9,09%	0%
Economy Field	60%	42,86%	35,71%	3,85%	0%	0%	0%
Education Field	10%	42.86%	28.57%	88.46%	80%	81.82%	100%
Military Field	0%	0%	14.29%	3.85%	20%	18.18%	0%
Environment Field	30%	14.29%	21.43%	3.85%	0%	0%	0%
Properties Speed	20%	28.00%	42%	50%	80%	0%	25%
Properties Skills based	60%	100%	50%	23%	60%	0%	100%
Properties Intelligence	100%	42%	42%	88%	40%	100%	50%
Properties Precision	0%	28%	14%	42%	20%	45.00%	25%
Properties Reflection	20%	57%	28%	96%	40%	100%	25%
Properties Decision	100%	85%	100%	42%	0%	0%	0%
Properties Funny	0%	14.00%	0%	38%	40%	27%	50%
Properties Knowledge	100%	100%	100%	76%	80%	54%	75%
Properties Chance	0%	42%	14%	3%	0%	0%	0%

Application of AHP for game genre selection : The Problem of game genre selection has been dealt with using a statistical study detailed above; the study has concerned several on-line serious games to extract criteria that will be used by the

AHP method to classify game genres according to the parameters chosen by the users. In this work, the AHP method is used to select the most suitable video game genre according to the parameters given by the users. In general, the AHP method consists of four main phases, including problem structuring, data collection, relative weight evaluation and problem solution establishment. The Figure 3-20 below explains the process followed to do the game genre selection by using the AHP method.

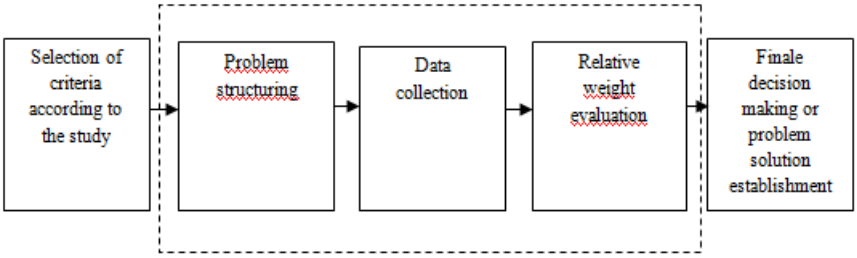

Figure 3-15: Game Genre selection using AHP method.

Problem structuring :

The problem structuring consists of decomposing a certain complex problem of decision making into a series of hierarchies where each level represents a smaller number of managed attributes. Among the rules to construct a good hierarchical structure for decision making, there are the clear definition of the decision problem and the determination of the main goal; the structure of the hierarchy from the top through the intermediate levels to the lowest levels. In Figure 3-16 the goal of the problem is located at level 0. Level 1 houses the major criteria and the level 2 contains all the sub-criteria. Finally, the alternatives are located at the last level of the hierarchy. The game genre selection criteria and the alternatives detail in Figure 3-16.

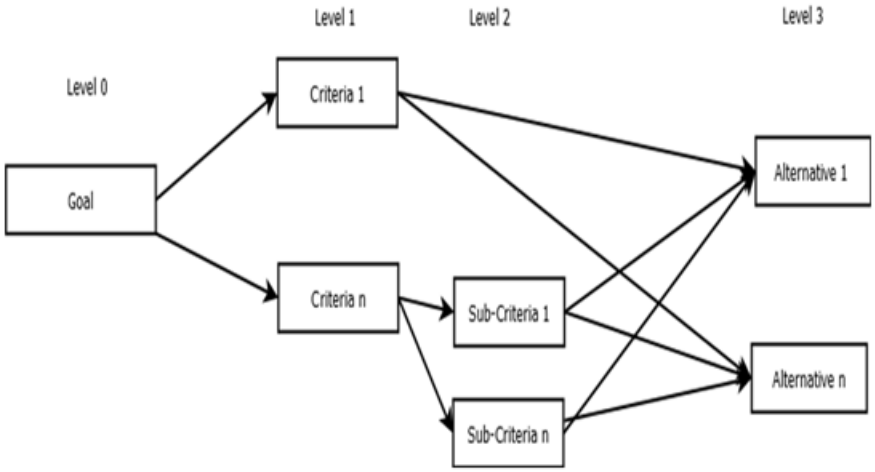

Figure 3-16: The AHP hierarchy example.

Data collection :

The second phase in AHP process consists of collecting data and its calculation. The decision maker assigns relative weight to pairs of attributes of a single hierarchy level, for all levels of the hierarchy, by using the most common scale of nine levels Table A.3.

The set of criteria is, composed of n elements C= C1, ., Cn . The result of the evaluation matrix in which every element $a_{i,j}$ (I,j = 1,2..,n) is the quotient of the weights of the criteria.

$$\text{A}=\begin{bmatrix} a\ 1,1 & \cdots & a\ 1,n \\ \vdots & \vdots & \vdots \\ a\ n,1 & \cdots & a\ n,n \end{bmatrix} =\text{a}_{11}=1,\ \text{a}_{ij}=1/\text{a}_{ji}\ ,\ \text{a}_{ij}\neq 0.\ (1)$$

Relative weight evaluation

In this phase of AHP method the pair-wise matrix, by pairs, transfers into problems of own value determination in order to get the normalized and a single eigenvector, as well as the weight of all attribute on each hierarchy level. Problem resolution: The problem resolution is the final phase of the AHP method and it involves the establishment of the so-called composite normalized vector. The determination of alternatives importance in the model comes next, within each criterion. The final step consists of synthesizing the total problem by being out in the following way: the

weight of each criterion is multiplied by the weight of the reviewed criterion, and these values are summarized for each alternative separately. The result is the weight of the reviewed alternative within the model. The weight of the rest of the alternatives is calculated in the same way; finally, the final ranking of alternatives is determined.

Consistency verification:

Saaty [123] recommended that the maximum eigenvalue, λ_{max} can be determined as:

$$\lambda_{max} = \sum_{j=1} a_{ij} w_j / w_i \quad (2)$$

Where λ_{max} is the maximum eigenvalue of positive real values in judgement matrix, w_j is the weight of the $j_t h$ factor, and w_i is the weight of i_{th} factor. Eigenvector X can be determined as:

$$(\mathrm{A} - \lambda_{max}\ \mathrm{I})\ \mathrm{X} = 0 \quad (3)$$

Saaty recommended using consistency index (CI) and consistency ratio (CR) to check for the consistency associated with the comparison matrix. Saaty demonstrated that for a consistent reciprocal matrix, the largest eigenvalue is equal to the number of comparisons, or λ_{max} = n. Then he gave a measure of consistency, called the consistency Index as a deviation or a degree of consistency using the following formula by using (3):

$$\mathrm{CI} = \frac{(\lambda_{max} - n)}{n-1} \quad (4)$$

Knowing the Consistency Index, we can calculate the consistency ratio (CR) by using (3):

$$\mathrm{CR} = \frac{CI}{RI} = \left[\frac{\lambda_{max} - n}{n-1}\right] / RI \quad (5)$$

Where RI represents average consistency index over a number of random entries of some order reciprocal matrices presented in Table 3.4.

Table 3.4: The reference values of RI different numbers

N	RI
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

The ratio of coherence can be interpreted as the probability that random matrix is full. The overall coherence of appreciation is assessed using the consistency ratio (RC). According to Saaty [123], if the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. Alternatively, if the Consistency Ratio is greater than 10%, the subjective judgement should be revised.

Application:

According to the theoretical part of this section we have implemented the hierarchical structure dedicated to game genre selection, it's composed of four levels; Level contains the main goal or objective selection of game genre. Level 1 there are three criteria "age, filed and properties", level 2 there are three sets of sub-criteria related for each criterion of level 1, in our case there are three sub-criteria related to age criterion, four sub-criteria related to field criterion and nine sub-criteria "Speed, Skills based, Intelligence, Precision, Reflection, Decision, Funny, Knowledge and Chance", related to properties, for the alternatives there are seven elements "RPG, RTS, Simulation, Platformer, Adventure, Puzzle and Flash" at the end of the structure, see Figure B-4. After implementation of hierarchical structure we can calculate the pair-wise comparison matrix for all levels existing in hierarchical structure.

Pair-wise comparison of level one:

The Matrix of Pair-wise comparison of level 1 concerns the three criteria "Age, Field, and Properties" is detailed in Table 3.5.

Table 3.5: First level attributes comparison

Goal	Age	Field	Properties	Weight
Age	1	3	1/4	0.23
Field	1/3	1	1/5	0.10
Properties	4	5	1	0.66

As can be seen from the table, we have given preference value to each criterion. The preference value (1/3) of field criterion to age criterion means that the age criterion is moderately important than field criterion. Correspondingly the Properties criterion is strongly more important than field and the properties criterion is also moderately more important than the age criterion.

$$\lambda_{max} = 3.08 \text{ ; CI= } 0.04 \text{ ; CR = } 0.04 < 0.1$$

Pair-wise comparison of sub level related to Age:

For the sub criteria related to age there are three ranges of age "3- 10, 10 18, +18", we decided to give all the elements the same value of priority "Equal importance", the pair-wise comparison matrix of sub level related to age is detailed in Table 3.6. For the calculation of global priorities, it depends on the range of age given by the user.

Table 3.6: Sub level age attributes comparison

-	C1	C2	C3	Weight
3-8 (C1)	1	1	1	0.33
10 -18 (C2)	1	1	1	0.33
+18 (C3)	1	1	1	0.33

$$\lambda_{max} = 3.0; \text{ CI} = 0.0; \text{ CR} = 0.0 < 0.1$$

Pair-wise comparison of sub level related to Filed:

For the sub criteria related to field there are four fields “Education, Health care, Economy and Environment”, we decided to give all the elements the same value of priority “Equal importance”, the pair-wise comparison matrix of sub level related to the field is detailed in Table 3.7. For the calculation of global priorities it depends on the field chosen by the user.

Table 3.7: Sub level field attributes comparison

-	C1	C2	C3	C4	Weight
Education(C1)	1	1	1	1	0.25
Health care (C2)	1	1	1	1	0.25
Economy (C3)	1	1	1	1	0.25
Environment (C4)	1	1	1	1	0.25

$$\lambda_{max} = 4.0;\ \text{CI} = 0.0;\ \text{CR} = 0.0 < 0.1$$

Pair-wise comparison of sub level related to Priorities:

For the sub criteria related to properties there are nine properties “Speed, Skills based, Intelligence, Precision, Reflection, Decision, Funny, Knowledge and Chance”, we decided to give all the elements the same value of priority “Equal importance”, the pair-wise comparison matrix of sub level related to properties is detailed in Table 3.8. For the calculation of global priorities it depends on the number of proprieties chosen by the user.

Table 3.8: A sub level property attributes comparison

-	Local weight
Speed	0.111
Skills based	0.111
Intelligence	0.111
Precision	0.111
Reflection	0.111
Decision	0.111
Funny	0.111
Knowledge	0.111
Chance	0.111

λ_{max} = 9.0; CI = 0.0; CR = 0.0 <0.1

Pair-wise comparison of alternatives :

For the proposed hierarchical structure there are seven genres "RPG, RTS, Simulation, Platformer, Adventure, Puzzle and Flash", the Pair-wise comparison has to be calculated by the local and global weight for each sub criterion connected to each game genre the tables from Table 3.9 to Table 3.24.

Table 3.9: Local weights of sub criterion [3 10] years

-	**Local weight**
RTS	0.054
RPG	0.030
Simulation	0.019
Flash	0.257
Platformer	0.214
Puzzle	0.214
Adventure	0.209

λ_{max} =7.86; CI = 0.14; CR = 0.1 <0.1

Table 3.10: Local weights of sub criterion [10 18] years

-	**Local weight**
RTS	0.261
RPG	0.261
Simulation	0.261
Flash	0.40
Platformer	0.92
Puzzle	0.40
Adventure	0.40

λ_{max} =7.11; CI = 0.01; CR = 0.01 <0.1

Table 3.11: Local weights of sub criterion [+18] years

-	Local weight
RTS	0.139
RPG	0.139
Simulation	0.424
Flash	0.074
Platformer	0.074
Puzzle	0.074
Adventure	0.074

$\lambda_{max} = 7.03$; CI = 0.006; CR = 0.004 <0.1

Table 3.12: Local weights of sub criterion education

-	Local weight
RTS	0.022
RPG	0.054
Simulation	0.029
Flash	0.174
Platformer	0.174
Puzzle	0.174
Adventure	0.371

$\lambda_{max} = 7.31$; CI = 0.05; CR = 0.03 <0.1

Table 3.13: Local weights of sub criterion health care

-	Local weight
RTS	0.088
RPG	0.100
Simulation	0.170
Flash	0.088
Platformer	0.290
Puzzle	0.170
Adventure	0.088

$\lambda_{max} = 7.14$; CI = 0.02; CR = 0.01 <0.1

Table 3.14: Local weights of sub criterion economy

-	Local weight
RTS	0.419
RPG	0.227
Simulation	0.162
Flash	0.047
Platformer	0.047
Puzzle	0.047
Adventure	0.047

$\lambda_{max} = 7.11$; CI = 0.01; CR = 0.01 <0.1

Table 3.15: Local weights of sub criterion environment

-	Local weight
RTS	0.339
RPG	0.137
Simulation	0.222
Flash	0.075
Platformer	0.075
Puzzle	0.075
Adventure	0.339

$\lambda_{max} = 7.02$; CI = 0.004; CR = 0.003 <0.1

Table 3.16: Local weights of sub criterion speed

-	Local weight
RTS	0.060
RPG	0.060
Simulation	0.140
Flash	0.191
Platformer	0.457
Puzzle	0.027
Adventure	0.062

$\lambda_{max} = 7.21$; CI = 0.03; CR = 0.02 <0.1

Table 3.17: Local weights of sub criterion properties skills based

-	Local weight
RTS	0.104
RPG	0.328
Simulation	0.074
Flash	0.033
Platformer	0.104
Puzzle	0.020
Adventure	0.332

$\lambda_{max} = 7.52$; CI = 0.08; CR = 0.06 <0.1

Table 3.18: Local weights of sub criterion intelligence

-	Local weight
RTS	0.293
RPG	0.043
Simulation	0.043
Flash	0.177
Platformer	0.043
Puzzle	0.332
Adventure	0.067

$\lambda_{max} = 7.21$; CI = 0.03; CR = 0.02 <0.1

Table 3.19: Local weights of sub criterion reflection

-	Local weight
RTS	0.042
RPG	0.108
Simulation	0.064
Flash	0.283
Platformer	0.108
Puzzle	0.283
Adventure	0.108

$\lambda_{max} = 7.06$; CI = 0.01; CR = 0.007 <0.1

Table 3.20: Local weights of sub criterion precision

-	Local weight
RTS	0.033
RPG	0.110
Simulation	0.034
Flash	0.302
Platformer	0.077
Puzzle	0.409
Adventure	0.032

$\lambda_{max} = 7.25$; CI = 0.04; CR = 0.02 <0.1

Table 3.21: Local weights of sub criterion decision

-	Local weight
RTS	0.317
RPG	0.197
Simulation	0.317
Flash	0.086
Platformer	0.026
Puzzle	0.026
Adventure	0.026

$\lambda_{max} = 7.47$; CI = 0.07; CR = 0.05 <0.1

Table 3.22: Local weights of sub criterion funny

-	Local weight
RTS	0.042
RPG	0.066
Simulation	0.042
Flash	0.157
Platformer	0.237
Puzzle	0.103
Adventure	0.350

$\lambda_{max} = 7.14$; CI = 0.02; CR = 0.01 <0.1

Table 3.23: Local weights of sub criterion knowledge

-	Local weight
RTS	0.244
RPG	0.244
Simulation	0.244
Flash	0.065
Platformer	0.102
Puzzle	0.032
Adventure	0.065

$\lambda_{max} = 7.12$; CI = 0.02; CR = 0.01 <0.1

Table 3.24: Local weights of sub criterion chance

-	Local weight
RTS	0.081
RPG	0.437
Simulation	0.153
Flash	0.081
Platformer	0.081
Puzzle	0.081
Adventure	0.081

$\lambda_{max} = 7.02$; CI = 0.003; CR = 0.002 <0.1

For the global weights related to each alternative, they are calculated dynamically according to the parameters given by the users via the web application.

The Results of game generation : As said before the users will use a web application that implements the AHP algorithm, and according to the parameters given by them, the application will rank the game genres by summing the global weight of each criterion. For example if the user chooses these parameters "age = 15 that belongs to the interval (10 18), filed = Education and the properties checked is knowledge, Decision and Intelligence", see Figure 3-17.

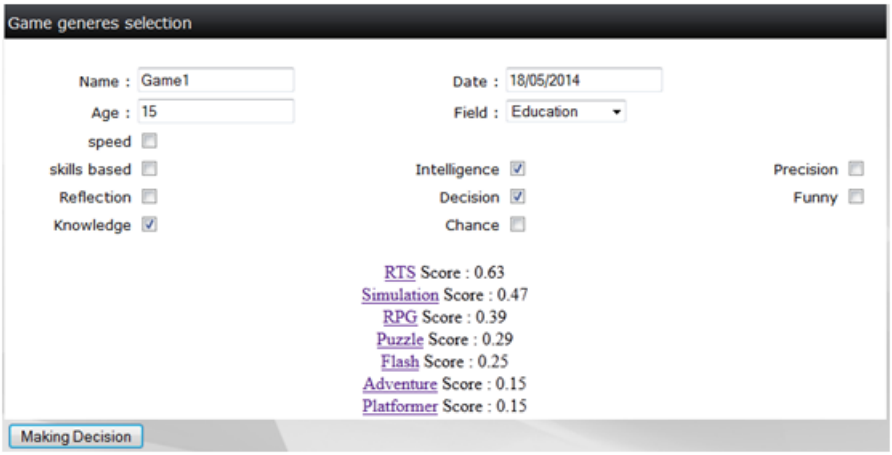

Figure 3-17: The web application developed by our research team for game genre selection based on The AHP method.

Table 3.25: Total weighted score of games genres

-	C1	C2	C3	C4	C5	C6	C7
[10 - 18]	0.060	0.060	0.060	0.009	0.021	0.09	0.09
Education	0.002	0.006	0.003	0.018	0.018	0.018	0.038
knowledge	0.162	0.162	0.162	0.043	0.068	0.021	0.043
Decision	0.211	0.131	0.211	0.057	0.017	0.017	0.017
Intelligence	0.195	0.029	0.028	0.118	0.029	0.221	0.045
Total score	0.63	0.39	0.47	0.25	0.15	0.29	0.15

"RTS = C1, RPG = C2, Simulation = C3, Flash = C4, Platformer = C5, Puzzle = C6 and Adventure = C7". According to the results (Table 3.25) found in the game genre selection, RTS appears to be the best choice of all seven game genres based on its highest total score. The results found through the AHP implementation were reliable as the evaluation criteria matched the case game genre selection, pair-wise comparison were made via informed judgements and were consistent, and mathematical calculations were completed and validated through the algorithm implemented on the web application.

Scenario establishment based on gameplay bricks

After the selection of game genre according to the parameters selected by the user and the AHP ranking algorithm described in the section above, the user can build his own scenarios by using the scenario editor in Figure 3-18.The use of the scenario editor will make the task very easy by dragging and dropping the gameplay bricks, message bricks, media bricks and game object bricks to form one main block that contains all the game mechanics, messages, and media components that will be included in the generated video game.

This concept of the scenario editor is based on the visual programming concept [127], where the user can manipulate program elements graphically. Each brick can be parametrized according to the need of the user; with the proposed interactive web interface, the user can create a variety of scenarios, without the interaction of any expert in game design neither the game developers.

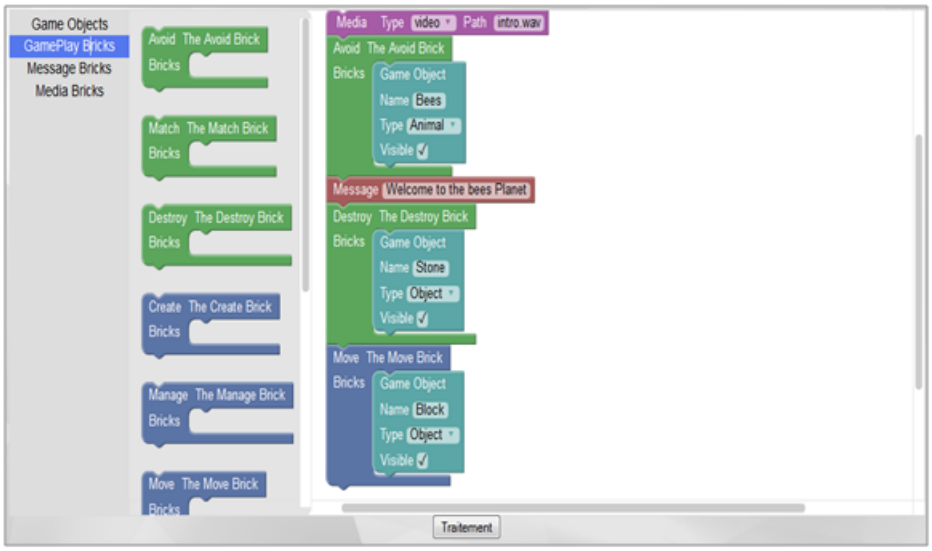

Figure 3-18: The scenario web interface based on gameplay bricks.

Levels establishment

The level design is a discipline in the process of game development involving the creation of stages, missions or map locations. In most cases the levels of video games are established either by level editors or game development software designed for building

levels. In the proposed game generator this step comes after scenario establishment and the level editor used in this step is based on a JavaScript library to generate web based video games. In addition, with the use of the objects of palette the user can place objects and characters in different places on the map of level Figure 3-19. Then he can set up the level with the possibility to test the course of the scene of the video game, to see the unfolding of objects, in order to modify it if necessary.

Figure 3-19: The level editor of the proposed game generator.

Fuzzy expert system

As mentioned above, the game generator will be equipped with a fuzzy expert system, its main role is the support of the users via the notifications that will guide them to generate video games that are educational and fun. In this section we will present the fuzzy expert system, and its design and implementation.

Introduction to fuzzy expert system : The fuzzy expert system in [128, 129, 130, 131], is an expert system that uses a fuzzy logic in [132], instead of Boolean logic; more precisely is a collection of membership functions and rules that are used to reason about data, in general it's composed of three units: Fuzzifier, inference engine and Defuzzifier, see Figure 3-20.

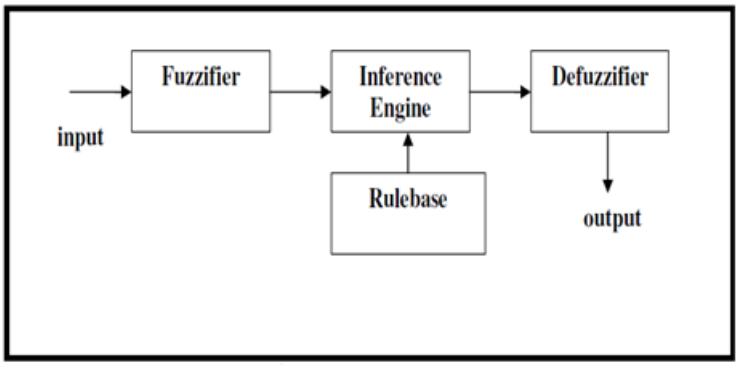

Figure 3-20: Fuzzy expert system architecture.

The Fuzzy expert system is categorized into two types:

- First is fuzzy control system that accepts inputs as numbers then the input number is translated into a linguistic term. In fuzzy control system the application domain is defined.

- The second type is fuzzy reasoning which attempts to emulate human thinking where the domain is not defined. Such system deals with numbers and linguistic variables.

The process of fuzzy logic follows successive steps, in the beginning the crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables through the fuzzy linguistic terms and membership functions, this step is known as Fuzzication. Then, an inference is made based on a set of rules. In the end, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the Defuzzication step, the fuzzy logic algorithm is explained below:

1. Define the linguistic variables and construct the membership functions (initialization).

2. Construct the rule base (initialization).

3. Convert crisp input data to fuzzy values using the membership functions (Fuzzification).

4. Evaluate the rules in the rule base (inference).

5. Combine the results of each rule (inference).

6. Convert the output data to non-fuzzy values (Defuzzification).

Linguistic Variables:

Linguistic variables are the input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values. A linguistic variable is generally decomposed into a set of linguistic terms.

Membership Functions:

Membership functions are used in the Fuzzication and Defuzzication steps of a fuzzy logic system, to map the non-fuzzy input values to fuzzy linguistic terms and vice versa. There are different forms of membership functions such as triangular, trapezoidal, piecewise linear, Gaussian, or singleton.

Fuzzy Rules:

A rule base is constructed to control the output variable. A fuzzy rule is a simple IF-THEN rule with a condition and a conclusion.

Defuzzication:

After the inference step, the overall result is a fuzzy value. This result should be Defuzzied to obtain a final crisp output. This is the purpose of the Defuzzier component of a fuzzy logic system. Defuzzication is performed according to the member ship function of the output variable.

Modeling the fuzzy expert system : The establishment of any complex system requires a design process composed of different steps followed by the designer to build it; in this perspective there are many steps that make the implementation of fuzzy expert system possible with a result that respects the need related to concerned field. The Process of designing a fuzzy expert system can be pursued using the following steps:

Specify the need and define the linguistic variables

The specification of the need is always the first step to begin the design of any complex

system, including the fuzzy expert system; in this step the designer has to describe the need that leads to build the fuzzy expert system for the concerned field. When the need is specified, comes then the definition of linguistic variables that take linguistic values e.g. “Age is old” to determine the fuzzy sets thereafter.

The specification of the need:

The idea is to equip the game generator by the fuzzy expert system that will accompany the users during the creation process of their own serious games; by giving them indications and instructions that will help them to create both educational and entertained games.

Define linguistics variables :

There are three main linguistic variables for the fuzzy expert “FES”: Educational Gameplay bricks, Entertaining Gameplay Bricks, and Neutral Gameplay Bricks, Table 3.25.

Table 3.26: Linguistic variables and their numerical ranges

Linguistic variable : Educational Gameplay bricks		
Linguistic value	Notation	Numerical range
low	L	[0 ,25, 50]
medium	M	[25, 50,75]
high	H	[50 ,75, 100]
Linguistic variable : Entertaining Galepmay Bricks		
low	L	[0 , 25, 50]
medium	M	[25 , 50,75]
high	H	[50 ,75, 100]
Litguiltic variable : Neunras Gameplay Bricks		
low	L	[0 ,25, 50]
medium	M	[25 ,50, 75]
high	H	[50 ,75, 100]

Fuzzification : For each input and output variable selected, we define two or more membership functions (MF), normally three but can be more. We have to define a qualitative category for each one of them.

Determine fuzzy sets:

Fuzzy sets can have a variety of shapes. However, a triangular or a trapezoidal can often provide an adequate representation of the expert knowledge, and at the same time, significantly simplifies the process of computation.

$$\begin{cases} 0 & x < min \\ \frac{x-mid}{low-mid} & min \leq x \leq mid \\ \frac{x-mid}{max-mid} & mid < x \leq max \\ 0 & x > max \end{cases}$$

Triangular: f (x|min, mid, max)

$$\begin{cases} 0 & x < min \\ \frac{x-mid}{low-mid} & min \leq x < low \\ 1 & low \leq x \leq high \\ \frac{x-mid}{max-mid} & high < x \leq max \\ 0 & x > max \end{cases}$$

Trapezoidal: f (x|min, low, high ,max)

The Fuzzy sets in FES:

All the Fuzzy set of the Fuzzy expert system are presented in the Figure 3-21.

Figure 3-21: Fuzzy sets of the Fuzzy Expert System.

Construct the fuzzy rules : To accomplish this step the designer of the system has to describe how the problem can be solved using the fuzzy linguistic variables defined previously. The required knowledge can be collected from different sources such as computer databases, flow diagrams and observed human behaviour, interviews with experts of the fields. The Table A.4 resumes all the rules that define our fuzzy expert system.

Defuzzification : During the Defuzzification the value for each variable is calculated using the selected Defuzzification method, which can be:

- Centre of gravity: $\frac{\int x\mu(x)dx}{\int \mu(x)dx}$
- Centre of gravity singleton: $\frac{\sum_i xi\ \mu i}{\sum_i \mu i}$
- Center of area: $u \mid \int_{-\infty}^{u} \mu(x)\,dx = \int_{u}^{\infty} \mu(x)\,dx$
- Rightmost Max: arg maxx $[\mu(\mathrm{x}) = \max(\mu(\mathrm{x}))]$
- Leftmost Max: arg minx $[\mu(\mathrm{x}) = \max(\mu(\mathrm{x}))]$
- Mean Max: mean(x) $\mid \mu(\mathrm{x}) = \max(\mu(\mathrm{x}))$

In our case we have used the center of gravity Defuzzification method, it consists of finding the centroid of the area bounded by the controller output membership functions and its abscissa is taken as the crisp controlling value [133, 134, 135]. The Center of Gravity method takes into account the rules and at the maximum membership level. It has the disadvantage of not allowing control actions towards the extremes of the action range [136].

3.2.5 Results of the game generator

As mentioned before, the process of game generation is composed of three main steps described in the sections above. In each step the user does some manipulation in order to pass to another step.

In the first step the user chooses the game genre based on AHP algorithm, then he establishes the video game scenario by using the gameplay bricks, during the scenario establishment the fuzzy expert system will validate this step, by controlling the combination of gameplay bricks , messages bricks and media bricks in order to create a scenario that is both educational and entertaining, the fuzzy expert system will notice the user by giving him indications and instructions, in the example illustrated in the Figure 3-22, the user has to add two entertaining gameplay bricks “Avoid , Shoot” one neutral gameplay brick “Media” and one educational gameplay brick “Message”.

The fuzzy expert system has shown a message alert mentioned that the generated serious game will be more entertaining than pedagogical; therefore, the user has to add more educational gameplay bricks. The message shown on the screen will be changed according to the interpretation of the fuzzy expert system algorithm which takes into account the number of each type of gameplay bricks added by the user, after validation of this step, he can establish the levels of video game by building the map and dragging and dropping several “2D, 3D” objects and characters into the map.

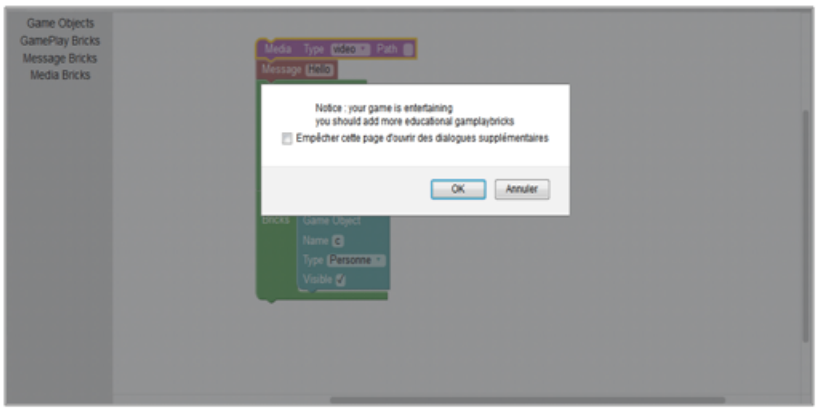

Figure 3-22: Instruction given by the fuzzy expert system to the user.

After stepping through all steps of the generative process, the end result is the generation of a serious game which is intended for the user specification. The generated video game is a cross-platform view that is developed by using the JavaScript libraries and APIs; therefore, it needs just a web browser to be run, and it is both educational and entertaining, because during the establishment of the scenario the user has used a combination of educational gameplay bricks that is able to transmit messages and knowledge to the learners that play the game, and he has also used the entertaining gameplay bricks that creates envy and desire into them to play more during game progression. Among the features of the game generator is the possibility to modify the generated video game, this feature will offer to the user the flexibility to modify the scenario or the level to address all issues related to the wrong implementation of the scenario, levels of the video games, pedagogical objectives and entertaining mechanisms that will be included into the generated video games.

According to the selection of game genre, the game generator will be able to generate pltaformer video games, see Figure 3-23, flash video games, see Figure 3-24 ,and other video game genres, which will create a diversity of serious games generated. The first game is the prototype “sweetlands” where the players use a bunny character that has to jump using mouse clicks to avoid falling, then further on the game, the user should use the mouse to catch bonus. The educational objective of this game is to teach young kids to use the mouse of the computer.

Figure 3-23: Screen-shot from the generated platformer video game.

In order to value the learning and the assessment of the pedagogical objectives we gave the game to 5 kids who never used a computer before. We gave them a test where they have to click 10 spots on the screen using the specific order, and then we made them play the game until they gave up playing, then we made the test with the 10 spot, and here are the results Table 3.27:

Table 3.27: Table of results by learner

	Before	**After**
Kid1	16s	12s
Kid2	12s	9s
Kid3	15s	11s
Kid4	18s	12s
Kid5	10s	8s
AVG	14.2	10.4

From this study we noticed that the kids enjoyed playing the game, and concerning the educational objective we saw a clear improvement of the speed, around 26.77% faster than the first attempts. The second prototype game witch is called “Qiup”

it's a small flash game where the user should guess the next geometry. The main pedagogic objective of this game is to train the brain and rise up the I.Q of the player.

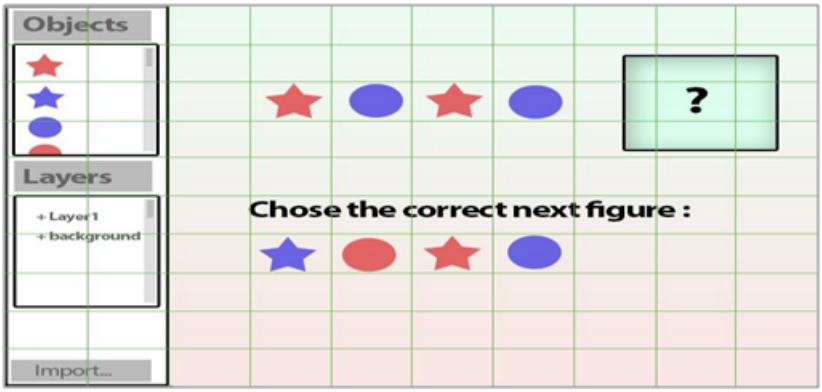

Figure 3-24: Screen-shot from the editor video game (flash genre).

3.2.6 Conclusion

The fact of developing a game generator that will allow the non-experts to create their own serious games, will let them save the time and the cost of development of such video games and in addition, it will allow them to focus more on the educational aspect and pedagogical objectives, instead of wasting more time on conception and development of the video games. With the integration of fuzzy expert system the proposed game generator will be able to guide users during the video game generation process , in this case the proposed video games generator will play the role of the expert. The proposed video game generator is limited because it needs a lot of "3D, 2D" graphical resources to be generic, and the development of a full multi-genres video game generator requires a lot financial and personal resources.

3.3 Players performances analysis based on educational data mining case of study: interactive waste sorting

Serious games have become one of the most powerful tools in the education field, owing to their capability to transmit the knowledge to the players/ students, but to judge if a given serious game is effective, there must be a system that analyzes the performances and behaviours of the players, to see their level of understanding of a particular topic proposed by the serious game. In this perspective of research and development this part presents a method for analysis concerning the performances of serious game players, based on educational data mining, with the aim of helping the instructors and the experts to improve their strategies of teaching.

3.3.1 Introduction

The serious games are designed to have an impact on the target audience, which is beyond the pure entertainment aspect [137, 138]. This kind of video games, has for mission the transfer of the knowledge to the learners in an entertaining way. Among the features proposed by serious games there are : the attractiveness, the interactivity, the system of assessment, and the transfer of different pedagogical messages in a different way, with those features serious games have become one of the most powerful tools in educational field this last decade.

Obviously the most important criteria that judges the efficiency of a serious game is its potential to teach new skills and its capability to transmit the knowledge to the learners in a playful way; in addition, one of the challenges that face instructors and experts is how to evaluate the learning outcomes in order to identify if the given serious game is suited for a given goal or field, for this reason many studies have been done concerning the potential educational benefits that serious games may offer, but the problems are finding reliable measures for learning, and one of the biggest challenges has been finding accurate and reliable measures for fun and learning [139].

In addition, the method followed to analyze such measurement can be a decisive view of its importance and its role that it plays for helping the instructors and experts to improve their methodology of teaching according to the performances and the behaviours of the students / players.

In summary, this part presents a method that analyses the player's performances based on educational data mining of a serious game developed by our research team and dedicated to children; the proposed serious game is about the protection of environment field, and its concept is simple, the player has to drag and drop different objects and put them in the correct container according to their types, but the novelty is the way of interaction between the player and the serious games by using a controller that senses how naturally player move hands and fingers to drag and drop different objects, all gestures and behaviours of the players will be saved in the database then processed by an algorithm called k-means for clustering; as a final step the result given by k-means clustering algorithm will be used by the instructors and experts to classify their students according to their performances, in order to detect problems met by the learners/ players during their learning process.

3.3.2 The concept of waste sorting serious game

The main objective of the proposed serious game is to teach kids how to recycle different waste. The player should sort different waste into trash, paper, plastic, metal, glass, and organic. The sorting is done by catching different objects generated randomly and dropping them in the appropriate container according to their types, this mechanism will be done by using a tool called a leap motion controller, see Figure 3-25.

The waste sorting serious game will be equipped by the timer, and the assessment system that evaluates the players according to their performances; if they make a good choice the reward will be the gain of some points, however in the opposite case the punishment will be the loss of some points. With the assessment system, the timer, and the interactivity based on hand movement, the proposed serious game will be more challenging and attractive especially for kids, it will allow them to live a

beneficial and unforgettable experience.

The proposed serious game has been developed by JavaScript API, therefore, it need just a web browser to be run.

Figure 3-25: Screen shoots from waste sorting video game.

3.3.3 Educational data mining

The Data Mining is the process of analyzing data from different perspectives and summarizing the results as useful information. It has been defined as the non trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data [140, 141].

Among the most famous branches of data mining there are the educational data mining "EDM" that describes a research field concerned with the application of data mining, machine learning algorithms and statistics tools to the information generated from educational area.

Other definition of educational data mining as a tool of Mining in educational environment, concerns developing new methods to discover knowledge from educational databases [142].

It's an emerging discipline, concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in [143].

The knowledge discovering process

The knowledge discovering process "KDD" includes selecting the data used in data mining process, this data can be obtained or extracted from different and heterogeneous data sources e.g. "database, files, etc". As shown in Figure 3-26 data mining including educational data mining is an essential step in the process of knowledge discoveries.

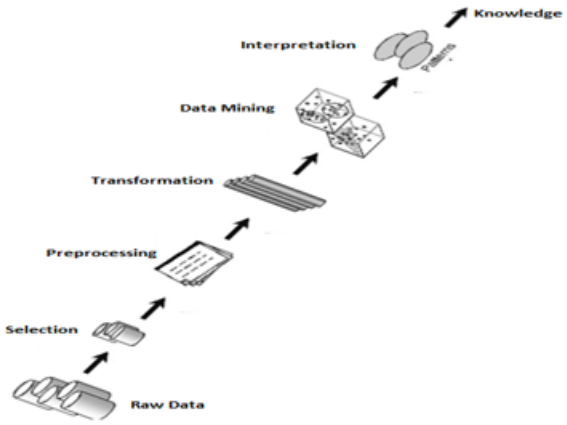

Figure 3-26: knowledge discovering process Data mining method.

Data mining techniques

Obviously the main objective of data mining is both prediction and description. That is, to predict unknown or future values of the attributes, while describing the data in a manner understandable and interpretable to users. For this reason there are several methods regrouped in several different classes described below: Association rule, Clustering, Classification, Regression, and Neural networks.

Association rule: Mining association rules searches for interesting relationship among items in a given data set [144]. It's used to find frequent item set finding among large data set. Association Rule algorithms need to be able to generate rules with confidence values less than one. However the number of possible Association Rules for a given dataset is generally very large and a high proportion of the rules are usually of little value.

Types of association rule:

- Multilevel association rule.
- Multidimensional association rule.
- Quantitative association rule.

Clustering: Clustering is applied to position items of heterogeneous data resources in to specific groups according to some attributes. By using clustering techniques it's possible to identify dense and sparse regions in object space, and correlations among data attributes. It can be used as a tool to distinct groups or classes of objects but it becomes costly to clustering.

Types of clustering methods:

- Partitioning Methods
- Hierarchical Agglomerative (divisive) methods
- Density based methods
- Grid-based methods
- Model-based methods

Classification: Classification is a data mining task that predicts group membership for data instances [145]. It's the most commonly applied data mining technique, which employs a set of pre-classified patterns to develop a model that can classify data.

Types of classification models:

- Decision tree
- Bayesian Classification
- Neural Networks
- Support Vector Machines (SVM)
- Classification Based on Associations

Regression: Regressions techniques can be adapted for prediction. In general the regression analysis can be used to model the relationship between independent and dependent variables. In data mining independent variables are attributes already known and response variables are what users want to predict [146].

Types of regression methods:

- Linear Regression
- Multivariate Linear Regression
- Non-linear Regression
- Multivariate Non-linear Regression

Neural networks: The typical neural network consists of nodes that are connected to each other and exist in several different layers, resulting in its being often referred to as a Multi Layered Perceptron (MLP) network. These layers are the input layer, the hidden layer, and the output layer. Each of these layers has a design with specific amount of individual nodes in them. An individual node works much like its biological counterpart the neuron.

It receives input from a multitude of different weighted input connections, sums these inputs and then produces an output that serves as input for other nodes. This output is generally normalized to be between -1 and 1 and typically a sigmoid function of the type discussed and can be used for this [147].

Types of neural networks:

- Back Propagation

3.3.4 The Method

As mentioned in the section above the knowledge discovering process data mining method is composed of different steps, in this section we will detail the process followed in order to analyze the players performances by using educational data mining especially k-means algorithm for clustering.

The knowledge discovering process

As mentioned above the serious game will be equipped by a database, see the class diagram in Figure 3-27, the information like gestures, score, number of good choices, bad choices, and all the behaviours of the player, in addition to the personal information as age and name will be saved in this database. All of this information will help instructors to analyze player's performances by feeding the k-means algorithm in order to group the students according to their performances.

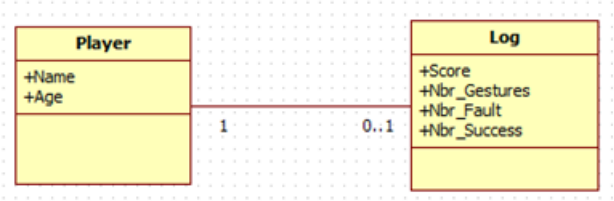

Figure 3-27: Class diagram of the log system of the proposed serious game.

WEKA Data mining software

The Waikato Environment for Knowledge Analysis "WEKA" came about through the perceived need for a unified workbench that would allow researchers easy access to state of the art techniques in machine learning. It is recognized as a landmark system in data mining and machine learning [148]. It has achieved widespread acceptance within academia and business circles, and has become a widely used tool for data mining research. The book, in [149], that accompanies it's a popular textbook for data mining and is frequently cited in machine learning publications. This Workbench contains a collection of visualization tools and algorithms for data analysis and predictive modelling, together with graphical user interfaces for easy access to this functionality.

The Graphical user interface Chooser WEKA's graphical start point has undergone a redesign and now provides access to various supporting user interfaces, system information and logging information, as well as the main applications in WEKA. Figure 3-28 shows the revamped GUI Chooser.

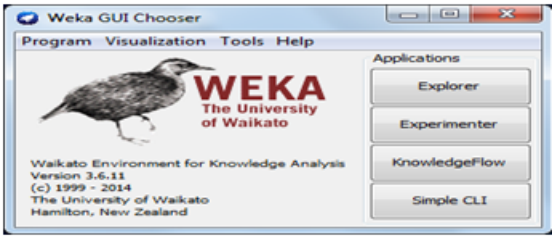

Figure 3-28: The GUI Chooser.

Scatter plots, ROC curves, trees and graphs can all be accessed from entries under the "Visualization" menu. The "Tools" menu provides two new supporting GUIs: SQL viewer and Bayes network editor. In addition to other features that make the use of WEKA more helpful for the users.

Definition of K-Means Clustering

The k-means algorithm, in [150], selects randomly k number of objects, each of which initially represents a cluster mean or centre, an object is assigned to the cluster to which it is most similar, based on the distance between the object and cluster mean. Then it computes new mean for each cluster. This process iterates until the criterion function converges, the flowchart of k-means algorithm shown in Figure B-5.

Clustering players with the use of k-means algorithm

As mentioned above the information saved during the serious game sequence from each player, are: score, number of gestures, number of good choices, number of bad choices and the age of the player. All this information will help teacher to analyze the performances of the players, the method consists of grouping the players according to their performances.

The choice of k-means algorithm is due to the fact that all informations recorded are digital, because some implementations of K-means only allow numerical values for attributes. With the use of the WEKA graphical user interface, the instructor can download data from database as shown in Figure 3-29.

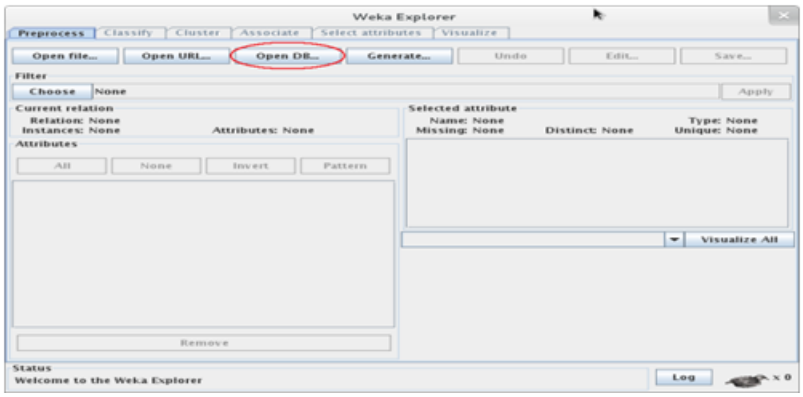

Figure 3-29: WEKA Explorer interface with the database loaded.

After the loading of the data from the database, the user can show the attribute that will be used by k-means algorithm in Figure 3-30.

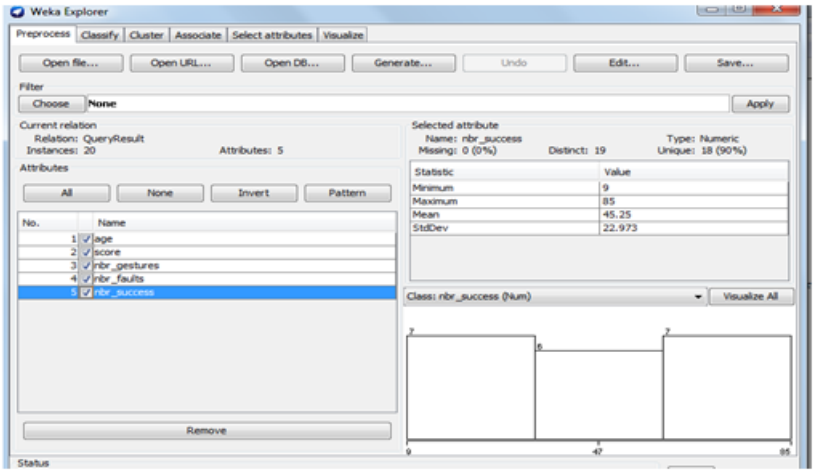

Figure 3-30: WEKA Explorer Preprocess Interface.

The Cluster interface from the WEKA GUI proposes several algorithms among them there are: SimpleKmeans, EM, Cobweb, xMeans, etc. In our case the user chooses the SimpleKMeans algorithm, and in addition he can use the parameters like number of clusters, seed and number of iterations. See Figure 3-31.

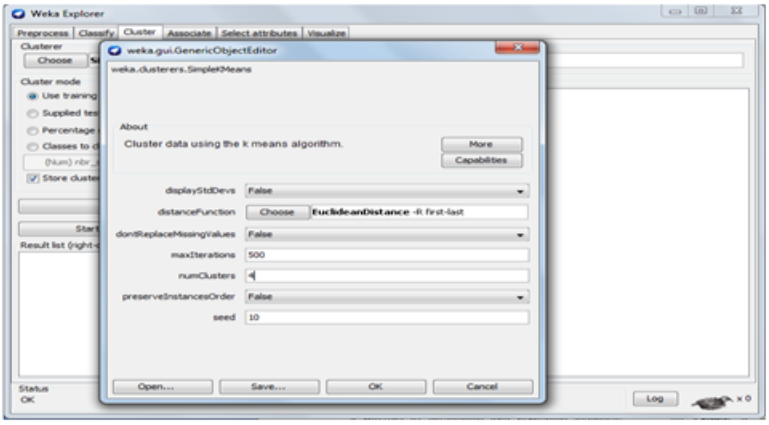

Figure 3-31: WEKA Explorer Cluster Interface.

The simpleKMeans algorithm automatically handles a mixture of categorical and numerical attributes. Furthermore, the algorithm automatically normalizes numerical attributes when doing distance computations. The WEKA simpleKMeans algorithm uses Euclidean distance measure to compute distances between instances and clusters. In the next section, we will detail and discuss the result obtained by the chosen algorithm.

3.3.5 Results

Once the options have been specified as number of clusters “4 clusters”, seed and the “Use training set” option is selected. The clustering algorithm will be run, the result of the algorithm shown in Figure 3-32.

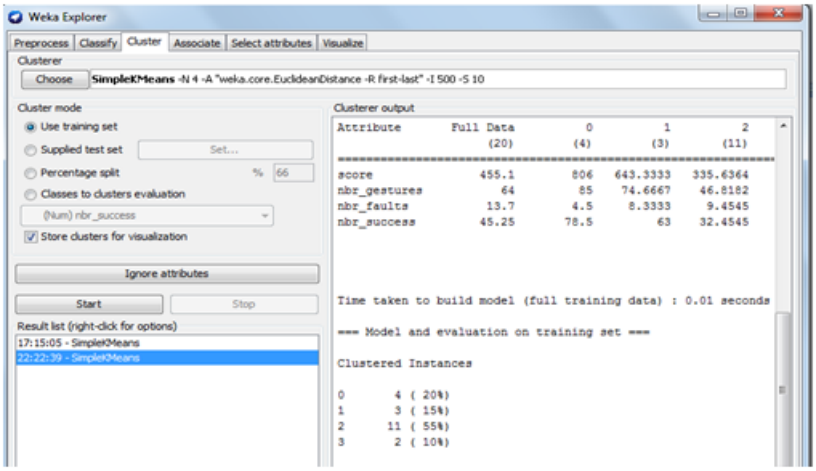

Figure 3-32: Result of K-MEANS Clustering.

There are 20 players concerned by this study, as a generated result there are four clusters, according to the score, number of gestures, number of good choices and bad choices. The clustering produced by k-means shows 20% (4 instances) in cluster 0, 15% (3 instances) in cluster 1, 55% (11 instances) in cluster 2 and 10% (2 instances) in cluster 3. In our case the simple k-means algorithm has done 7 iterations to cluster results, the within cluster sum of squared errors value is 1.1401, and the time taken to build model is about 0.01 seconds.

For more details the result shows that in cluster 0 the score is 805, the number of gestures is about 85, the number of good choices is 78.5, and the number of bad choices is 4.5. In cluster 1 the score is 643.33, the number of gestures is about 74.66, the number of good choices is 63, and the number of bad choices is 8.33. In cluster 2 the score is 335.6, the number of gestures is about 46.8, the number of good choices is 32.45, and the number of bad choices is 9.45. In cluster 3 the score is 128, the number of gestures is about 100.5, the number of good choices is 63.5, and the number of bad choices is 22.5. The cluster 0 covers 20% of players cluster 1 covers 15% of players, cluster 2 covers 55% of players and cluster 3 covers 10% of players.

Interpreting the results given by the simpleKMeans algorithm, the cluster 0 represents the good players/students who understood all the basics of waste sorting, according to their score and their performances. For the players that belong to the

cluster 1, they are generally good, but they need some guidance and explanation concerning the basics of the waste sorting. Taking the case of cluster 2 the students that belong to that cluster, have an average level, they have few problems regarding their understanding about the proposed topic and they need an explanation and assistance to understand the basics of waste sorting. For the final cluster 3, most of the students that belong to this cluster have several problems and difficulties, they have chosen the objects randomly and without thinking. They need explication on basics of waste sorting, and in addition they need a special assistance, in order to increase their level of comprehension. The percentage of each cluster is shown in the graph below Figure 3-33.

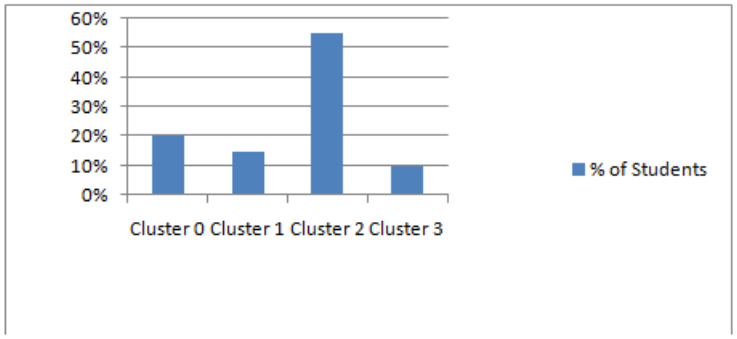

Figure 3-33: Graph concerning percentage of students in each cluster.

Another way of understanding the characteristics of each cluster is through visualization, the Figure 3-35 shows cluster representation according to the score compared to the number of gestures, we can visualize other result according to different combinations of score, number of gestures; and number of good and bad choices.

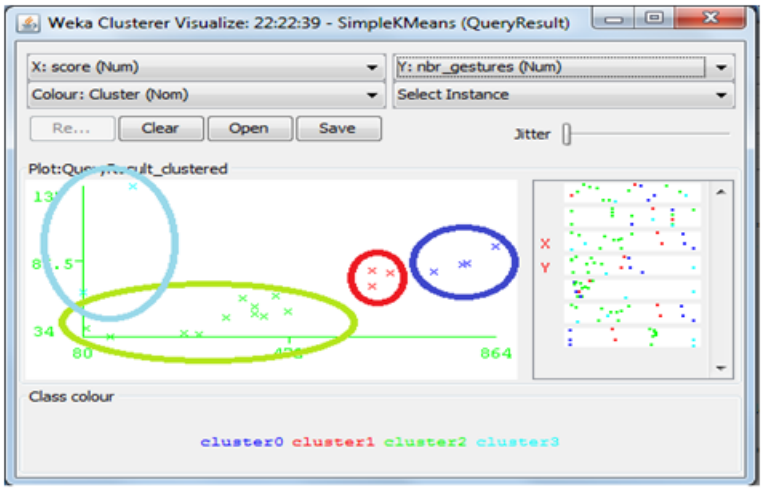

Figure 3-34: Visual result of weka tool.

The instructor can add age in his analysis to get information that will help him change his course to be better suited for these students. This analysis method based on collecting information about students during a sequence of serious game with the use of the educational data mining can be operated as needed and according to the learning strategy of the instructors.

3.3.6 Conclusion

To conclude this part, we can say that the use of this method can be beneficial for the instructors and the experts, and as more and more data is collected from the database concerning players information, the instructor can analyze the behaviours and performances of their students to understand their ways of learning, and have a global view of their interaction with the proposed serious game, with this method the instructor can improve his own strategy of teaching.

Concerning the perspectives we will envisage to equip the proposed serious game with other algorithms of educational data mining e.g. "classification, association rules", combined with learning analytics techniques in order to have other information about players, and it will be equipped with an inference engine that will analyze players' behaviours and give indication to them, as in their progression in the game. This approach will be a shift towards a smart serious game.

3.4 Towards a system of guidance assistance and learning analytics based on multi agent system applied on serious games

With the revolution that the education field has known concerning the new tools and ways of learning and especially the integration of new technology as instruments of teaching, several new tools have appeared and among these tools there are serious games, the latter as a new tool dedicated to education have occupied an important place, and replaced other tools often used in the learning process. But in order that serious games reach the intended objectives and help instructors to achieve their prospective objectives, it must be that this kind of video games will be equipped with a guidance and assistance system that will assist the learners during the progression of a sequence of the video game, and in addition they should be equipped with a system of learning analytics that will help instructors to improve the learning process and teaching methods according to the performances and feedbacks of their learners.

3.4.1 Introduction

Serious games or learning video games have for mission the transfer of the knowledge in a fun and interactive way; this feature has made this kind of video games one of the most powerful tools used for teaching and learning, and it is within the scope of using the new technologies in the educational field. For serious games to prove their effectiveness; they must be able to transmit knowledge properly and allow measuring and analyzing the learning outcomes. Unfortunately, it is a challenge in any video game to teach a player how to play and to guide him through the game world., especially when dealing with a serious game, the challenge intensifies due to the inherent variations in student backgrounds, making the choice of how to guide the student from the start to the end of the game without direct instructor interactions a complex problem [151]. In addition, the difficulties in measuring learning outcomes achieved through serious games use have been a main barrier for successful deploy-

ment and adoption of such video games within formal education [152]. There are several research works that were directed by different institutions and laboratories, concerning the inclusion of assistance and learning analytics system in serious games, among the types that exist there is a virtual instructor which is enabled by mobile augmented reality learning "MARL" games. They have the potential to provide a fun and educational experience. This kind of video games assist the learning conceptual knowledge as well as psycho-motor task in real world environments [153]. In the literature there are also methods and studies on the interaction of serious games with learning analytics system [154, 155, 156, 157].

With the aim to overcome the difficulties cited above, we will detail in this part the different steps of the establishment of a system that will be able to react with the learners by giving them information or assistance during their progression in the video game, this relationship will help learners to improve their learning level and also their performance. On the other hand, we will detail also the establishment of the system capable of saving data about learners in order to analyze them by using several algorithms, specific methods and techniques, the results of such analyses will help the instructors to improve both their strategy and their teaching methods, based on the feedback of their learners, the inclusion of such a system will make serious games a complete tool suitable for the process of the learning.

3.4.2 Theoretical background

The establishment of such system requires a specific architecture with the interaction of several technologies; therefore, we have used the combination of the rule-based inference engine, the educational data mining tool with the learning analytics techniques, all of those technologies will be hosted in different agents of the multi agent system, in this section we will detail the theoretical background of the multi agent system architecture and the technologies used in the establishment of the proposed system.

Rule-based inference engine

The main role of the inference engine is to drive new facts from the knowledge base as shown in the Figure 3-35, specifically the inference engine applied logical rules to the knowledge base, then inferred new knowledge, there are different types of inference engines, but in this part we will focus on rule-based inference engine which applies several rules with data to derive new facts. This kind of inference engine is always composed of three components, the interpreter that executes the chosen agenda elements by applying the corresponding base rules, the scheduler that maintains the control over the agenda by estimating the effects of applying inference rules in criteria on the agenda, the consistency enforcer that attempts to maintain a consistent representation of the emerging solution.

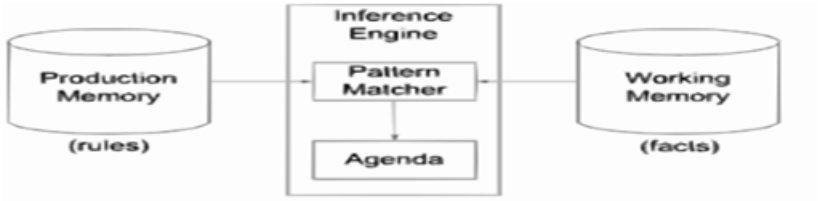

Figure 3-35: Inference engine architecture.

Generally, in every rule-based inference engines, there are two kinds of inference, backward chaining and forward chaining. In the forward chaining, according to this algorithm the inference is triggered by the arrival of new data in the working memory; it's also called data-directed inference. The backward chaining where inferences are not performed by the system is made to prove a particular goal; it's also called hypothesis driven, or goal directed inference.

Educational data mining

The Data Mining is the process of analyzing data from different perspectives and summarizing the results as valuable information. It has been defined as the non-trivial process of identifying valid, potentially useful, novel and ultimately understandable patterns in data [140, 141]. Among the most famous branches of data mining there

are the educational data mining "EDM" that describes a research field concerned with the application of data mining, machine learning algorithms and statistics tools to the information generated from the educational area. Other definition of educational data mining as a tool of Mining in educational environment, deals with developing new methods to discover knowledge from educational databases [142]. It's an emerging discipline, related to developing methods for exploring the unique types of data that come from educational parameters, and using those methods and techniques to better understand students, and the settings which they learn in [143]. There are several data mining techniques used to extract useful data that help users to predict unknown or future values of the attributes, and also to describe the data in a manner understandable and interpretable to users. Among those techniques there are Classification, Clustering, Association rule, Regression, and others machine learning algorithms like neural networks, Bayes network, etc.

Learning analytics

The learning analytics research tries to increasingly answer several questions about what a learner knows and whether a learner is engaged or not. The application fields of the learning analytics concern modelling of user knowledge, user behaviour, and user experience, user profiling; modelling of key concepts in a domain and modelling a domain's knowledge components, and trend analysis. Below we will detail those concepts.

The user knowledge modelling is the Collection of user's skills and knowledge extracted from different data sources, looking at the registered data that represents the interaction between user and both learning system or serious games. Among the information extracted there are: correctness of a student response alone or in a series, time spent on practice before attempting to answer a question or to do manipulations, number and nature of hints requested, allotment of wrong answers and errors made. Such inferences can be modelled by a predictive model or by a teacher looking at student data on a dashboard. A popular method for estimating students' knowledge is Corbett and Anderson's [158], knowledge tracing model, an

approach that uses a Bayesian-network-based model for estimating the probability that a student knows a skill based on observations of him or her attempting to perform the skill. More recently, a new study [159] has proposed a new method for knowledge tracing using a machine learning approach to make contextual estimations of the probability that a student has guessed or slipped. Incorporating models of guessing and slipping into predictions of student future performance was shown to increase the accuracy of the predictions by up to 48 percent. The User behaviour modelling in education often characterizes student actions as on- or off-task and can be used as a proxy for student engagement. It relies on the same kinds of learning data used in predicting user knowledge plus other measures, such as how much time a student has spent on-line, whether a student has completed a course, documented changes in the classroom or school context, attendance, tardiness, and sometimes a student's level of knowledge as inferred from his or her work with the learning system or from other such data sources as standardized test scores. Baker and colleagues have conducted a series of studies on detecting and adapting to students' off-task behaviours called gaming the system in adaptive learning systems that teach algebra [160].The User experience modelling ascertaining whether a student is satisfied with the learning experience can be judged by students' responses to follow-up surveys or questionnaires and by their choices, behaviours, performance, and retention in subsequent learning units or courses. User experience through methods other than data mining, collected time spent on redesigned course components, periodic surveys of students' motivation state during the course, and learning performance. The user profile is a collection of personal data describing the essential characteristics of a user. User profiling refers to the process of constructing and applying student or group profiles using data mining and machine learning algorithms. In educational data mining techniques, such as classification and clustering, they are often used to categorize learners based on the kinds of personal learning data.

Multi agent system

A multi agent system "MAS" is a computing distributed system, composed of a number of interacting computational entities, but the single difference between classical distributed systems and multi agent system is that the entities that interact in the system, are intelligent. These entities that react in the system are called agents, and must be able to communicate each other. The concept of multi agent system has influenced the initial developments in areas like cognitive modelling and instructional design [161, 162]. Until nowadays, the multi agent systems establish a major research subject in distributed artificial intelligence. MAS technology aims to create general and specialized behavioural and interaction models and to implement these models into distributed and interacting computer programs called agents. The design of such models follows certain guidelines that characterize agents [163]. The MAS has been used in many fields to simulate complex systems, such as decision support tools for distributed decision problems.

3.5 The Proposed Serious game

Waste sorting has and should become part of our daily life to improve our living environment. With the importance of the waste sorting and the benefits that it presents, to this effect many instructional experts have found that teaching the basics of waste sorting for kids since their young age can be beneficial for the environment and the economy. For this reason there is no more robust way to learn the basics of waste sorting better than the video games, because of their advantages such interactivity and playability that arouse the intention and the desire into the players to play more. In this perspective of development our research team has developed an interactive web based serious game for waste sorting dedicated for children that will be described in this section.

The concept of waste sorting serious game

The main objective of the proposed serious game in Figure 3-36, is to teach kids how to recycle different waste. The player should sort different waste into trash, paper, plastic, metal, glass, and organic, etc. The sorting is done by catching different objects generated randomly and dropped in the appropriate container according to their types, this mechanism will be done by using a tool called a leap motion controller. The waste sorting serious game will be equipped by the timer, and the assessment system that evaluates the players according to their performances; if they make a good choice the reward will be the gain of some points, however if it's the opposite case the punishment will be the loss of some points. With the assessment system, the timer, and the interactivity based on hand movement, the proposed serious game will be more challenging and attractive especially for kids; it will allow them to live a beneficial and unforgettable experience. The proposed serious game has been developed by JavaScript API, therefore, it needs just a web browser to be run.

Figure 3-36: Screen shoots from waste sorting video game.

Interactivity with Leap motion controller

The Leap Motion controller is a small device that can be connected to a computer using a USB. It uses infra-red (IR) imaging to determine the position of predefined objects in a limited space in real time. It can then sense hand and finger movements in the air above it, and these movements are recognized and translated into actions for the computer to perform. According to the official information founded in the official web site of leap motion , the Leap software analyzes the objects observed in

the device's field of view. It recognizes hands, fingers, and tools, reporting discrete positions, gestures, and motion. The controller's field of view is an inverted pyramid centred on the device in Figure 3-37. The effective range of the controller extends from approximately 25 to 600 millimetres above the device. The controller itself is accessed and programmed through Application Programming Interfaces (APIs), with support for a variety of programming languages, ranging from C++ to Python and JavaScript. The positions of the recognized objects are acquired through these APIs. The Cartesian and spherical coordinate systems used to describe positions in the controller's sensory space.

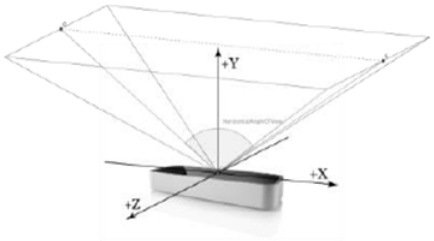

Figure 3-37: Leap motion's field of view.

With the features that leap motion controller offers and with the use JavaScript application programming interface, we have integrated it in the proposed video game, therefore, the player has to move his hand and catch the random generated objects in order to drag and drop them, then place them in a correct container. With this possibility the proposed video game will become more interactive and so close to the real case. That will create desire into the player to play more. In addition, this concept will allow us to save all gestures done by the players during a sequence of the video game; this data will be used by educational data mining to understand the player's behaviours and also to analyze their performances.

3.5.1 The establishment of the system

The system of guidance, assistance and learning analytics proposed in this part will be established via the use of the multi agent system; the chosen system is composed

of several entities called intelligent agents, where each agent of the system is equipped with a rules engine, data mining algorithms or the methods of the learning analytics. As shown in the Figure 3-38 there are different technologies used in the architecture of the proposed system, in the first place we have a web application deployed in the application server, this web application is composed of a web based serious game that interact with the server side by using Ajax technology, the use of the interactive interface allows real time interaction between the actions and the gestures of the learners and the appearance of the assistance messages that the system should provide to the learners to guide them in order to improve their performances.

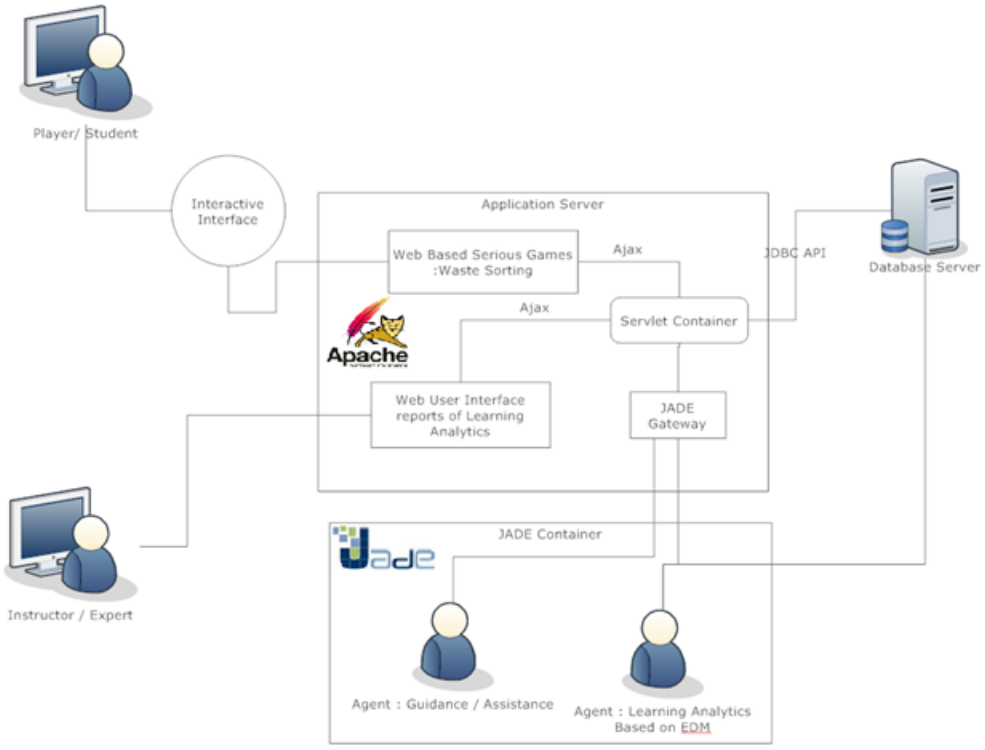

Figure 3-38: Architecture of the system based on MAS for guidance and Evaluation Concerning Serious Games Players.

Regarding the multi agent system part, Jade[5] has allowed us an easy implementation of the multi agent system "MAS", as presented in the scheme the MAS is composed of two intelligent agents; the first one is the guidance and assistance agent;

[5]http://jade.tilab.com

yet, the second agent is for learning analytics. Each agent reacts in its own way and implements its own algorithms to ensure the proper functioning of the whole system. As mentioned before the first agent is equipped with a rules engine, in order to build such engine we have chosen drools[6] a Business Rules Management System "BRMS" solution. It provides a core Business Rules Engine "BRE". We have established a rule tree in Figure B-6 that contains all the possible cases of figures that will guide and assist learners during their video game sequence and according to their performances. In the tree rules there are several elements; level one that represents the time of the serious game sequence, as presented in the tree there are three intervals of the time [120s to 90s], [90s to 30s] and [30s to 0s]. Level two represents the Number of hand gestures "NG" done by the player to place different objects in the several containers. In the level three "%NF" represents the number of faults divided by the number of gestures. In the level five "CF" represents the container that has the largest number of faults committed by learners. As for the last elements, there are several messages that will be displayed on the screen to assist the learners. All the messages shown by the rules engine are detailed in the Table A.5. The agent intercepts all the actions and gestures of the learners, and then interprets all the data to give the correct message that will be displayed on the screen, and then the learner will react according to the message already displayed on the screen, with the aim to improve his learning level.

The second agent will feed a back-end web-based application; this application will be used by the teachers and trainees. Its main role is to give a global view concerning the learners that play the video game, and show graphs and dashboard of learning analytics. The scheme in the Figure 3-39 presents the database that saves all the data concerning learners; this data will be interpreted by the educational data mining algorithms, in this case we have used clustering algorithm "K-means algorithm" that will cluster the learners according to their performances, then the result will be presented in pie flowchart. In addition the data recorded in the data base will be interpreted by learning analytics algorithms based on user profiling method that sorts learners according to their score, number of gestures, etc. there is another

[6]http://www.drools.org

information that will be given by the agent like grouping different kind of containers according to the number of good and bad choices done by the learner. All of this information will be viewed by the teachers in order to make a good decision to improve their manner of teaching.

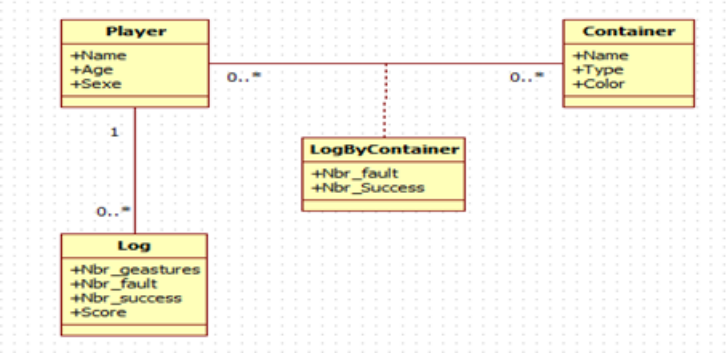

Figure 3-39: UML Class Diagram.

The communication between the web applications that hosts the web-based serious game and different agents is provided by the use of the jade gateway. This layer will ensure the communication between the separated systems and will allow them to function in harmony. In the next section we will detail the dashboard of the learning analytics, and also the kind of messages given by the rule engine that will guide and assist the learners.

3.5.2 Results

The intended result is a system composed of a web-based application with a multi agent system, the web-based application deployed in the server application was developed by using several technologies and tools e.g. "JavaScript APIs, Ajax, Java Technologies, Jade, Drools, and Weka". The combinations of these technologies have ensured the proper functioning of the system and despite the complexity associated with the implementation of such a system. The aforementioned web-based application is composed of two parts; the first part is a web-based serious game developed by using several JavaScript APIs that allow the creation of 2D video games on the web;

therefore, it needs just a web browser to be run, in addition, the interaction between learners and serious game is done through an interactive interface "leap motion" controller based on the hands and finger gestures. Figure 3-40 shows a screen-shot from the proposed web-based serious game about the waste sorting process; with the assistance's messages displayed on the screen to guide the learners during their performances and their progression in the video game. The second part is a back-end web-based application as a dashboard used by teachers and trainees in order to have a global view of their students; they can measure and analyze the performance of their students by using a combination of several educational data mining algorithms and learning analytics methods.

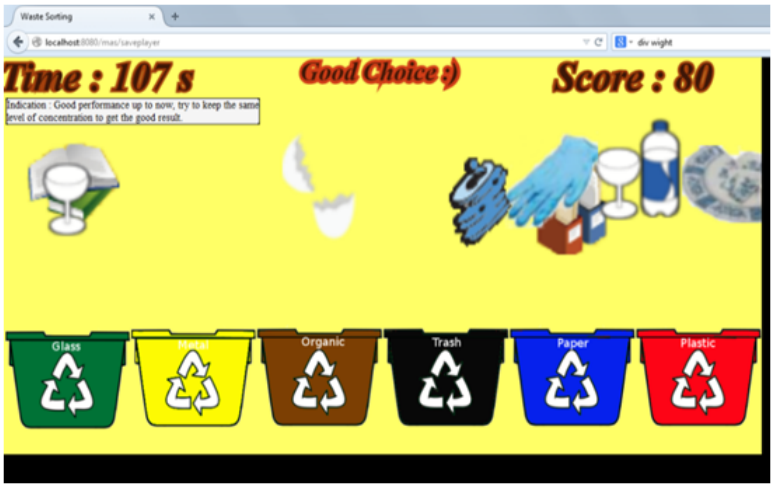

Figure 3-40: Screen-shot of the web-based serious game with the appearance of assistance message.

Figure 3-41 shows a pie chart about the user profiling that clusters several groups of learners according to their learning outcomes. The pie chart was fed by k-means cluster algorithm, in this pie chart there are four groups of learners grouped according to their performances, the orange part of the pie chart represents the good learners who understood all the basics of waste sorting, related to their score and the number of their hand gestures. For the learners that belong to the black part of the pie chart, they are generally good, but they need some guidance and explanation about the basics of the waste sorting. Taking the case of the green part of the pie chart the

learners belong to this part have an average level, they have few problems regarding their understanding about the proposed topic and they need an explanation and assistance to understand the basics of waste sorting. For the last part, the blue part most of the learners who belong to this part have several problems and difficulties, they have chosen the objects randomly and without thinking. They need explanation on basics of waste sorting, and a special assistance in order, to increase their level of comprehension. In the same web interface, there is a graph about a number of good and bad choices grouped by the type of the container. There is also a web interface that shows a graph about the learners' information, in this case we have presented the number of gestures and total score of each learner, as shown in the Figure 3-42. This web interface gives a global view on the activity of each learner that plays the serious game, and with this dashboard, the instructor can make decision, in order to improve and change his manner and strategy of teaching for the purpose of transmitting knowledge in a correct way.

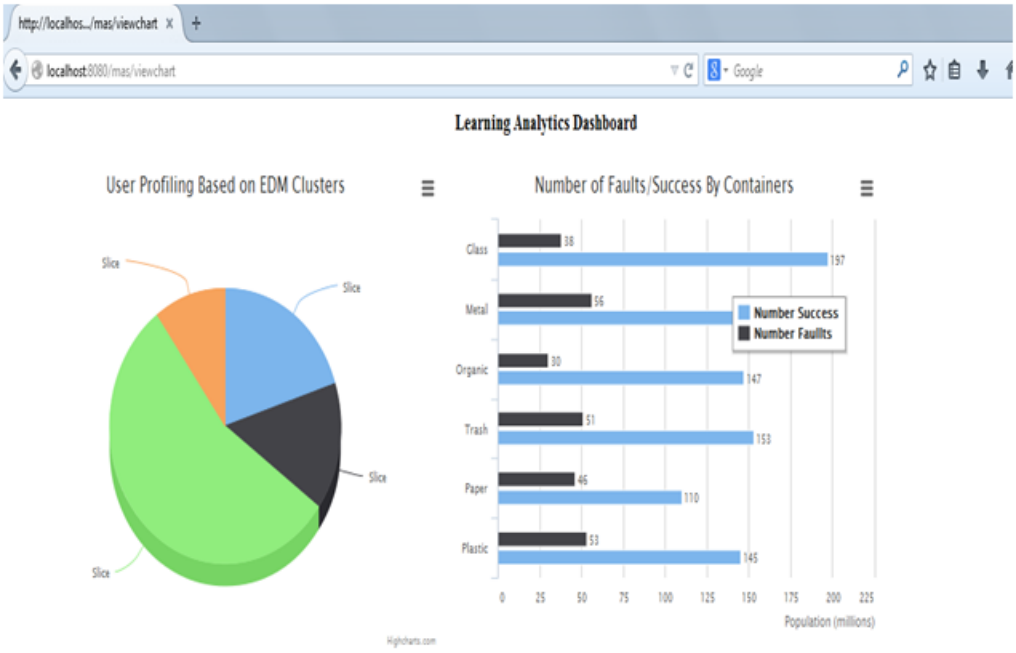

Figure 3-41: Screen-shot of the dashboard concerning User profiling and Number of faults and success by containers.

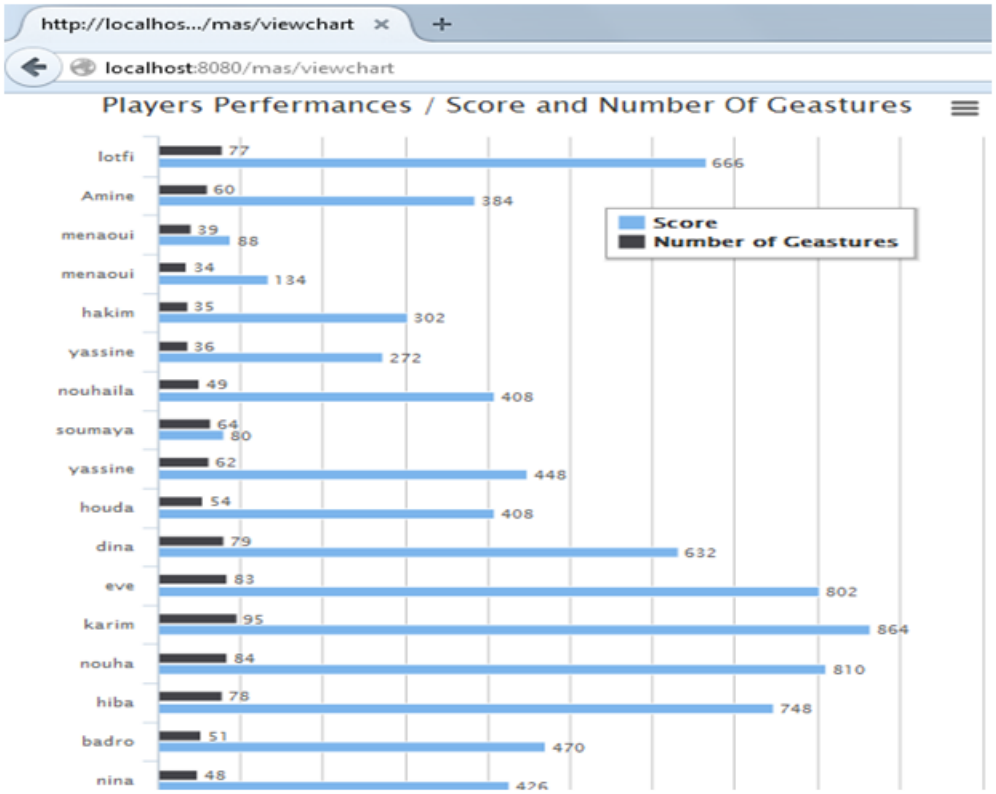

Figure 3-42: Screen-shot of the dashboard concerning learners' performances.

The serious game and the back-end web-based application communicate with guidance/assistance agent and learning analytics agent via a Jade Gateway; this interface insures a real-time communication between two heterogeneous environments web and multi agent system. In addition, the Dashboard application will enable teachers to adapt their teaching strategies and methods based on performance and the results of their students.

Comparing the approach followed in this part to establish the learning analytics system, with other approaches in other contributions [164, 165], we can conclude that the main objective of the proposed work and other contribution is to simplify teachers' task when using serious games by providing real-time information of the actual learners' use of the games while in the classroom. But the concept and the technologies used are different. In the other contributions the authors have used XML technology to deliver assessment data to the teachers, however in this part we have used a combination of educational data mining and learning analytics to extract

benefit information to the teachers so that they have a global view about the level of their learners allowing them to properly identify learners gaps. Regarding the assistance and guidance system, the authors of "solaris one serious game" [151], seek to first assess the student's skill to ascertain the amount and type of help to provide. Before each game, a set of multiple-choice questions are presented to find out what the student knows and where he may need help. In contrast our system represents an advantage because it reacts with learners automatically and according to their progress in the video game, which will allow learners to live a beneficial experience.

3.5.3 Conclusion

In this part we have detailed the establishment of guidance, assistance and learning analytics system based on a multi agent system, which will work in collaboration with a serious game developed by our research team. The proposed system has several advantages and benefits that concern both learners and instructors. One of the most important advantages of our system is its efficiency.On the one hand, it can assist and guide the learners, which will improve their level of understanding and accelerate their learning process and their analytical skills; the proposed system provides an environment both interactive and entertaining that carefully targets the knowledge that the learner must acquire. On the other hand, it will allow teachers and instructors to make their decisions easily. In order to improve their teaching methodologies, strategies and teaching manners. The decision will be made with the help of the dashboard that has several graphs and flowcharts which are fed by the learners' data interpreted via both educational data mining algorithms and leaning analytics methods. Among the perspectives envisaged there is the evolution of the current system by adding other agents equipped with other algorithms of the educational data mining, other learning analytics methods, and machine learning algorithms; the implementation of such system will open a new horizon for smart serious games.

3.6 Teaching arabic sign language through an interactive web based serious game

The teaching tools have known a big evolution with the integration of the new technology in the learning process, especially the serious games, thus the appearance of several input devices, e.g. "leap motion controller, kinect, etc.", has expanded the scope of the users which reaches people with disabilities e.g. "blind, deaf, etc.", how can also use this kind of video games. This part will detail the development of a web based serious game dedicated for deaf children, in order that they learn the Arabic sign alphabet, through both an input device called leap motion controller and hand gesture recognition based on the artificial neural network. The proposed serious game will be integrated in a learning management system via the use of the Scorm standards, in order to make the course on e-learning platform more interactive.

3.6.1 Introduction

More than two hundred million inhabitants of 22 countries across the Middle East and North Africa speak Arabic as native language [166]. A significant proportion of them are deaf, causing several communication problems with one other and also with people who speak the language. For this reason there are a set of sign languages called Arabic sign languages (ARSLs), but unfortunately ARSLs are still in their developmental stages. Only in these last years has there been an awareness of the existence of communities consisting of individuals with disabilities; the Deaf people are not an exception. Arab Deaf communities are almost closed ones. Interaction between a Deaf community and a hearing one is minimal and is basically concentrated around families with deaf members, relatives of the deaf, and sometimes play friends and professionals [167], for this a need appeared to unify Arabic sign language in all Arab countries. This drove the Council of Arab Ministers of Social Affairs (CAMSA) to take a decision of developing a unified Arab sign language dictionary and publish it to all countries, in an attempt to help Arab deaf people to have a common language

in addition to their local language [168].

To cope with these problems, it's important to encourage the little children with this handicap to learn the Arabic sign language, which will standardize communication despite the existence of different dialects in the Arab world. For this reason the best way to teach this language is the learning via serious games, thanks to their benefits, like interactivity, transfer of knowledge in a fun and attractive way. In addition the integration of input devices like "kinect, leap motion controller, etc." will allow this segment of special users to pass a good and beneficial time by playing the video games based on the gestures of their hands.

This part presents the development of a web-based serious game composed of two levels; the first one is in 2D environment whereas the second one is in 3D environment. The main objective of the proposed serious game is to teach the deaf learners the basics of the Arabic sign language through an input device called leap motion controller that detects both hand and fingers coordinates. These coordinates will feed the artificial neural network that will recognize the hand gesture performed by the learners. The proposed serious game will be integrated into a learning management system via the Scorm standards, in order to enrich the course and to create a variety of choices for the learners.

3.6.2 Related work

The appearance of several interactive input devices, e.g. "kinect, leap motion controller, etc." has expanded the scope of serious games, in order to cover other segments of users, e.g. "deaf and blind people", with the advantages of the serious games and the interactive input device, this special segment of learners will be able to learn in a fun way and live a beneficial experience. Until today several sign language video games have been developed by different laboratories and institutions. A team from the Superior Institute of Porto has developed a serious game in which the learner controls a character and interacts with various objects and non-player characters with the aim of collecting sever gestures from the Portuguese Sign Language [169]. Another performance of the team from Nova University of lisboa, has lead to a serious game

"Kinect-Sign" composed of two modes: School-mode and Competition mode. The first provides a school-like environment where the learner learns the letter-signs and the second provides the user with an environment used towards testing the learned skills. This serious game is based on the creation of a gesture library, relying on the Kinect depth camera; and the real-time recognition of gestures, by comparing the depth camera information with the existing gestures previously stored in the library [170]. The number of the serious games dedicated for deaf and dumb learners, is insufficient for the large number of the people who suffer from this handicap and especially for the learners from Arabic countries. In this perspective of research and development this section will present the development of a web-based serious game that teaches deaf kids the Arabic sign language through the leap motion controller.

3.6.3 Theoretical background

Arabic sign language

Arabic sign languages (ArSL) are not particularly different from other known sign languages, such as ASL and BSL. In fact, the Arabic varieties in use have undergone some lexical influence from other sign languages [171]. ArSL is limited to represent nouns, adjectives and verbs. Prepositions and adverbs are represented in the context of articulation by specifying locations, orientations and movement. Intensifiers are represented by iteration [167]. There are 29 hand gestures related to each Arabic sign alphabet as shown in Figure 3-43.

Figure 3-43: Arabic Sign Alphabets.

Artificial neural network

Artificial Neural Network (ANN) is a field of Artificial Intelligence that allows finding the data structures and algorithms for learning and classification of data, by inspiration from the human brain. The ANNs have been developed as generalizations of mathematical models of biological nervous systems. A first wave of interest in neural networks (also known as connection ist models or parallel distributed processing) emerged after the introduction of simplified neurons [172]. The basic elements of the neural networks are called artificial neurons, or simply neurons or nodes. All signals inside the network can be 1 or -1. The neuron calculates a weighted sum of inputs and compares it to a threshold. If the sum is higher than the threshold, the output is set to 1, otherwise to -1. A typical artificial neuron and the modelling of a multi-layered neural network are illustrated in Figure 3-44.

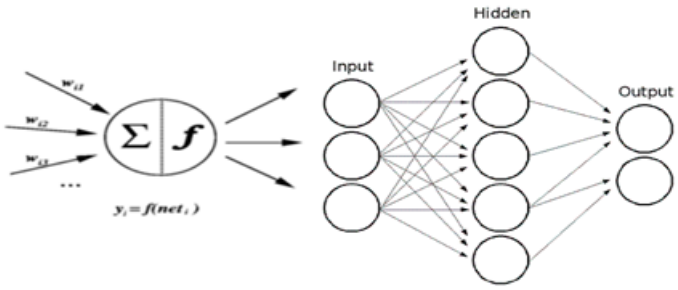

Figure 3-44: Architecture of an artificial neuron and a multi-layered neural network.

The signal flow from the inputs is considered to be unidirectional "in one direction". The neuron output signal O is given by the following relationship:

$$O = f\,(net) = f(\sum_{i=1}^{n} wi * xi)$$

Where w_i is the weight vector, and the function f (net) is referred to as an activation function. The variable net is defined as a scalar product of the weight and input vectors.

$$net = wT\ x = w1\ x1 + w2\ x2 + \ + wn\ xn$$

Where T is the transpose of a matrix, the output value O is computed as:

$$O = f\,(net) = \begin{cases} 1, & if\ wT\ \&x \geq \\ 0, & otherwise \end{cases}$$

Where is called the threshold level; and this type of node is called a linear threshold unit.

The most common architecture used to implement a neural network is composed of three layers the input, hidden, and output layers. In neural networks, the signal direction begins from the input towards the output elements, through one or several hidden layers of neurons followed by an output layer of linear neurons. Multiple layers of neurons with non-linear transfer functions allow the network to learn non-linear

relationships between input and output vectors. The Perceptron is a single layer neural network whose weights and biases could be trained to produce a correct target vector when presented with the corresponding input vector [173]. One of the most important features of artificial neural networks is their ability to learn. There are many different algorithms that can be used when training ANNs, each with their own advantages and disadvantages. The learning process within artificial neural networks is a result of altering the network's weights, with some kind of learning algorithm, e.g. "Perceptron Learning algorithms, Back-Propagation, Bayesian Learning".

In this part, the algorithm chosen for learning the Perceptron is the Gradient Descent algorithm. The Gradient Descent is an algorithm that involves finding the minimum of a complicated non-linear function called "error function". This function describes the error that the neural network makes in approximating or classifying the training data, as a function of the weights of the network. The main objective is to reduce error in order to become as small as possible and should thus try to move towards the point of minimum error [174]. The delta rule [Gradient Descent] algorithm described below:

- Initialize w = small random numbers
- Until termination condition is met (error bound, or iterations of training examples)
  - Initialize allΔwi $\leftarrow$ 0
  - For each training example (x, t)
    - Compute the output of each node: O(x)
    - For each weight unit wi: Δwi $\leftarrow$ Δwi $+\eta$(t-o)xj
  - For Each weight unit wi: wi $\leftarrow$ wi + Δwi

Among the feature of data rule [Gradient Descent] algorithm:

- Attempts to minimize the squared error of the training examples

- Guaranteed that there is a single minimum error

- Uses Sigmoid nunctiof σ(x): 1/(1+e-x)

- d σ(x)/dx = σ(x)(1- σ(x))

- The sigmoid function is used because the derivative is very easy to find

- Gradient: ∇E[w] = [dE/dwo, dE/dw1, dE/dw2,.., dE/awn]

- Training Rule: Δw = -$\eta\nabla$E[w]

Technical standard for e-learning software SCORM

The Sharable Content Object Reference Model (SCORM) was created to help the reusability, interoperability, portability, access, maintenance and adaptation of Learning Objects [175]. It's a collection of standards and specifications that allows the research, the importation and the integration of the content in several learning platforms e.g. "LMS, CMS, LCMS".The Learning Objects must be created for the SCROM Standards to ensure interoperability across the different tools and e-learning platforms, in [176], see the Figure 3-45.

The SCORM standards are XML-based industry formalization and the high level requirements defined for learning contents in SCORM are content reusability, accessibility, durability, and interoperability. SCORM enables the reuse of web-based learning content across multiple environments and products. Clearly, it is not a model for learning content; but it is a model for content delivery [177].

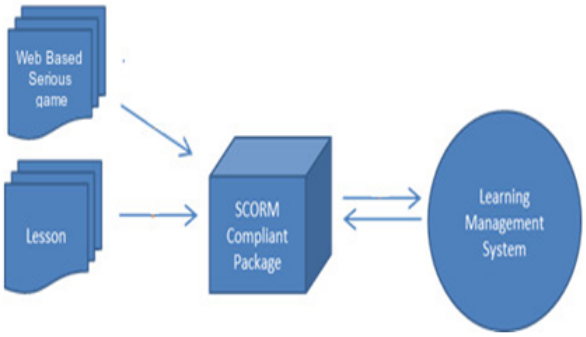

Figure 3-45: Integration of SCORM Standard with LMS.

3.6.4 Hand gesture recognition

As motioned before the proposed serious game will be equipped with an input device called leap motion controller that will track the hand gestures "palm and finger positions in 3D coordinate", and with the neural network that will recognize the hand gesture of the player. The gesture recognition process diagram is illustrated in Figure 3-46.

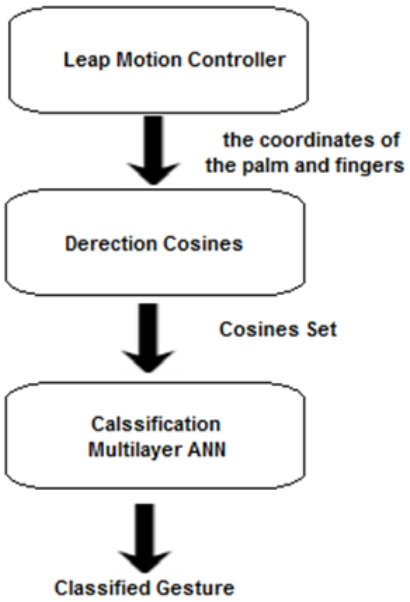

Figure 3-46: Block diagram of the recognition system.

Leap motion controller

The Leap Motion controller is a small device that can be connected to a computer using a USB. It uses infra-red (IR) imaging to determine the position of predefined objects in a limited space in real time. It can then sense hand and finger movements in the air above it, and these movements are recognized and translated into actions for the computer to perform. According to the official information found in the official web site of leap motion , the Leap software analyzes the objects observed in the device's field of view. It recognizes hands, fingers, and tools, reporting discrete positions, gestures, and motion. The controller's field of view is an inverted pyramid centred on the device, see Figure 3-47 . The effective range of the controller extends from approximately 25 to 600 millimetres above the device. The controller itself is accessed and programmed through Application Programming Interfaces (APIs), with support for a variety of programming languages, ranging from C++ to Python and JavaScript. The positions of the recognized objects are acquired through these APIs. The Cartesian and spherical coordinate systems are used to describe positions in the controller's sensory space.

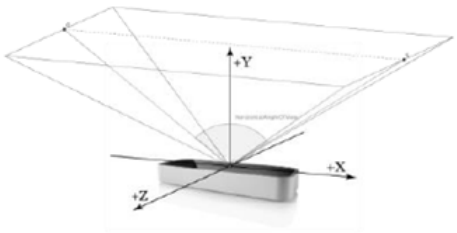

Figure 3-47: Block diagram of the recognition system.

With the features that leap motion controller offers and with the use JavaScript application programming interface, both integrated in the proposed video game; therefore, the player has to move his hand and catch the random generated objects in order to drag and drop them, then place them in a correct container. With this possibility, the proposed video game will become more interactive and so close to the real case. That will create desire into the player to play more. In addition, this concept will al-

low us to save all gestures done by the players during a sequence of a video game; this data will be used by educational data mining to understand the player's behaviours and also to analyze their performances.

The hand gesture tracking

Among the features of the leap motion controller is the tracking of the hand gestures by giving the 3D coordinate "x, y, z" of the palm and tip of each finger as in Figure 3-48.

Figure 3-48: Palm and Tip Positions given by the leap motion controller.

Thereafter, these coordinates will be used to calculate the direction cosines of each vector that will be constructed according to the 3D coordinates of the palm position and the 3D coordinates of the tip position of each finger:

$$\mathrm{A} = \mathrm{A}_x\ \mathrm{i} + \mathrm{A}_y\ \mathrm{j} + \mathrm{A}_z\ \mathrm{k}$$

Magnitude of a Vector:

$$\mathrm{A} = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Direction Cosines:

$$\cos(\alpha) = \frac{A_x}{A}, \cos(\beta) = \frac{A_y}{A}, \cos(\lambda) = \frac{A_z}{A}$$

$$\cos(\alpha)^2 + \cos(\beta)^2 + \cos(\lambda)^2 = 1$$

The direction cosines of each vector, in our case the five vectors related to the tip of each finger and the palm will feed the input of the neural network, in Figure 3-49, that will be intended to recognize the hand gesture of the learner. The input layer is composed of 15 nodes, each node is fed by Cosine values, and the set of the three cosines represent the direction cosines of each finger. The hidden layer is composed of four nodes, and in the output layer there is one node that will give either 1 or 0. The Table 3.28 describes some characteristics of the used neural network.

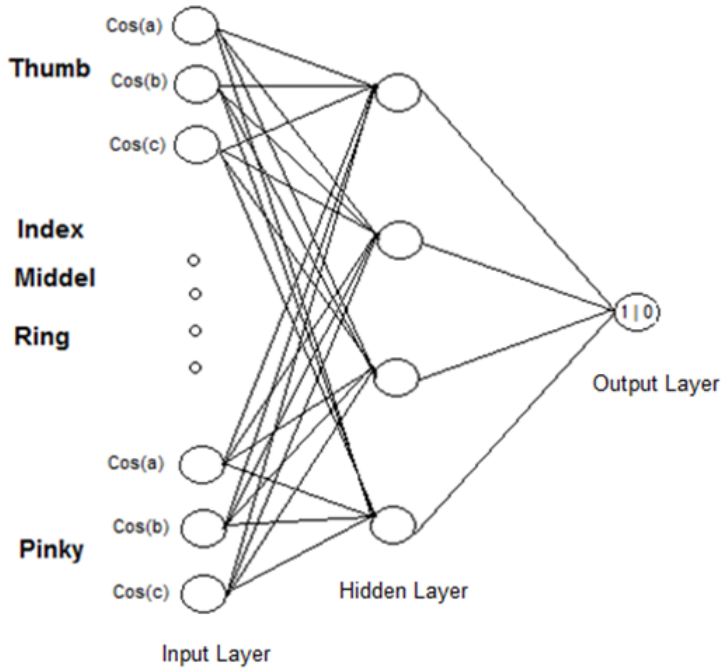

Figure 3-49: The neural network of hand gesture recognition.

3.6.5 Arabic sign language serious game

The proposed web-based serious game was developed by using several JavaScript APIs, e.g. "2D, 3D video game engines, ANN JavaScript API, etc.", in order that the video game will be run in different web browsers. The game architecture, detailed in the Fig 90 is composed of different modules related to each others, with the aim to make a full system that begins by tracking the hand gesture "coordinates, direction

Table 3.28: Characteristics of the artificial neural network

Element	value
Input layer	15 nodes
Hidden layer	4 nodes
Output layer	1 node
Activation function	Sigmoid
Legrnina algorithm	Gradient Descent
Threshold	0.9
TraTning error ihreshold	0.0001
Training iteration	20000
iearnLng rate	0.1

cosines" until the hand gesture recognition and the evaluation of the sign performed by the learner. This web based video game is composed of two game levels; each level has specific characteristics such as in the level one the environment of the game is 2D while level two is 3D. Level one will be played by using an input device "leap motion controller" based on hand gesture that will allow deaf learners to perform several hand gestures that will match the Arabic letters displayed on the screen.

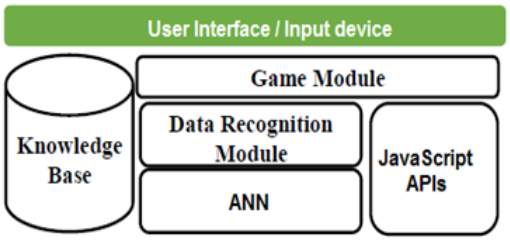

Figure 3-50: Web-based video game architecture.

The scenario of the level one, in Figure 3-51, is simple the learner has to perform the sign that will match the letter displayed on the screen, for each good answer the learner will win some points that will be added to his score, otherwise, he will lose points from his score. The learner must respect the time "three minutes" and try to increase his score by giving the right response.

Figure 3-51: Screen-shot from the level one of the proposed 2D web-based serious game.

The level two in Figure 3-52, of the proposed serious game is in 3D; it's developed according to the First-person shooter genre. The main objective of this level is letting the learner to live another experience different from the level one, and that will create a desire into him to continue playing the video game, in this level the learner must find all the cubs that randomly move in the maze, the number of the cubs depends on the picture displayed on the screen, because each cube represents a sign, with the collection of these cubs in the right order the player will construct the name of the object "picture" displayed on the screen. To make the game more challenging the developers have added in this level some obstacles that the learner must avoid. In general, the learner loses the game when the score becomes 0. When the learner collects the cubes in the right order other pictures will be randomly displayed as his progress in the game.

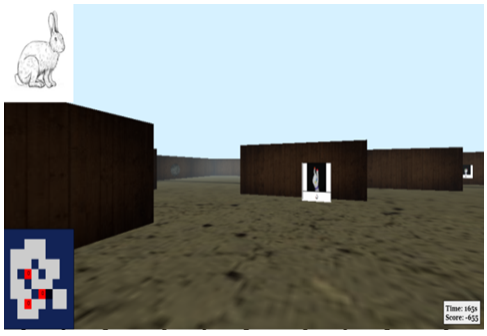

Figure 3-52: Screen-shot from the level two of the proposed 3D web-based serious game.

3.6.6 RESULTS

The development process has led to the creation of a web-based serious game composed of two levels, the first one is in a two-dimensional environment, equipped with an input device that tracks the hand gesture to extract the coordinates between the palm position and each tip position; these coordinates will be used to calculate the direction cosines, each calculated cosine will feed the inputs of the neural network in order to recognize the hand gesture performed by the learner, then the recognized gesture will be checked if it matches the letter displayed on the screen. The second level is in a third dimensional environment, this level adopts the game genre called the First person shooter (FPS), the diversity of environments will allow the learner to support a diverse experience that will create a desire in him to play.

As mentioned before the neural network who will take care of hand gesture recognition, is integrated into the proposed web based serious game "level one", this neural network is a multilayer Perceptron with activation function "sigmoid", the input layer of the proposed neural network is composed of fifteen nodes, four nodes as hidden layer, and one node as output layer. The learning algorithm used to train the network is the Gradient Descent, with 20000 training iteration, 0.1 as the value of the learning rate and threshold is 0.9.

Some of the results given by the neural network are detailed in the Figure 3-1, e.g. "the first four Arabic sign language". To explain more the algorithm used to match a performed gesture made by the learner with the letter that corresponds to it, the neural network gives the approximate values calculated from the gesture performed by the learner and the 29 patterns "correspond to each Arabic letter"; afterwards the algorithm selects the Max value from the set of the calculated values, the order of the chosen value corresponds to the order of the chosen letter, in this way the algorithm implemented in the web-based serious game recognizes the gesture performed by the learner then evaluate it to add some points to the global score or vice versa.

The proposed web-based serious game was integrated in a learning management system (LMS) "moodle [7]", see Figure 3-53 and 3-53, via the Scorm standards designed

[7] http://www.moodle.org

to enable the interoperability, accessibility, and re-usability of web-based learning content. The main objective of the integration of the web based serious game into LMS is to add more interactivity in the course and also change the way of learning by introducing an entertaining tool that will attract attention of the learner.

Figure 3-53: Screen-shot from the level one integrated with Scorm in to the Moodel LMS.

Figure 3-54: Screen-shot from the level two integrated with scorm in to the Moodel LMS.

In order to asses the full system, the proposed game was given to 10 deaf kids to evaluate their level of learning by saving the time and the score of each learner, according to the three game attempts Table 3.29.

Table 3.29: The learner outcomes since the three attempts of the level one of the web-based serious game

	1 Attempt		2 Attempt		3 Attempt	
	Time	Score	Time	Score	Time	Score
Learner 1	180s	150	180s	210	180s	250
Learner 2	60s	0	180s	100	180s	190
Learner 3	180s	130	73s	0	180s	125
Learner 4	130s	0	70s	0	180s	100
Learner 5	180s	200	180s	250	180s	220
Learner 6	50s	0	140s	0	180s	10
Learner 7	180s	30	170s	0	180s	90
Learner 8	180s	25	180s	105	180s	65
Learner 9	30s	0	180s	55	175s	0
Learner 10	180s	45	180s	100	180s	120

According to the results given in the Table 3.29, most learners have known an evolution of their level of learning, the score increase from an attempt of the game to another. This evolution of the learning level depends from a learner to another, the improved level of learning in the learner depends on several factors including his ability of analysis, his way of performing the gesture, his speed, his concentration, his ability to interact with the game, his motivation in addition of other factors that can influence his performance.

3.6.7 Conclusion

This part has discussed the development of a web-based serious game dedicated for deaf kids to learn the Arabic sign language, the use of the input device has changed the traditional method to play a video game that often exploits the keyboard or the mouse; with this new device the game has become more interactive and more

beneficial, because the learner can perform several hand gestures and he can correct them if he performed them in a wrong way. In addition, this method of learning based on serious game has allowed the learners to increase their level of learning and to undergo a new experience different from the traditional course that they are accustomed to follow. Concerning the future research works, the research team will integrate other levels of the game, in order that the learners learn the Arabic numbers and some special signs concerning communication. Also we integrate other devices e.g. "kinect" in the proposed serious game to allow learners to experiment these devices, and their interaction with serious games.

Chapter 4

Conclusion

4.1 General conclusion

In this thesis, we have presented a research work concerning the serious game design, serious game development, web-based serious game generator, learners' outcomes analysis, and application of serious games to solve specific issues. As mentioned above the followed working methodology has allowed us to reach all research objectives specified in the introduction phase. All the publications included in this thesis have been published in international journals, and each publication has responded to a specific research problem. In this research work, we have started to realize a state of the art concerning e-learning systems, serious games, game design methodologies, game engines, and application of serious games in several fields. The main objective of this part was to focus on the research works already carried out, acquire a solid knowledge of the field in question, launch our research on solid bases, and in addition to the reformulation of new ideas that will make our research more interesting and fruitful.

In order to reach the objectives of the proposed thesis, we started firstly by studying both instructional design methodologies and game design methodologies in order to create our design methodology that will be able to design serious games. This new methodology was based on a combination of the rapid prototyping model, a methodology often used in the field of instructional design, with other game designs;

we have modified the steps involved in each phase of the methodology in order, to make it more adapted to design a serious game and adapted also for the non-experts. The methodology has been tested during the creation of some serious games in different fields, e.g."religion, healthcare, laboratory analysis, etc.", and the results were satisfying.

The instructors need to have a serious games generator, that will allow them to create several serious games without the interaction of the game designer nor the development team, which pushed us to think about a suitable solution; this solution consists in developing a web-based serious game generator that can generate several video games according to the chosen game genre. The concept of the game generator is simple, based on three essential steps: in the first step the user passes his criteria, then an algorithm of multi-criteria decision making will rank the game genres, the second step based on the establishment of the scenario by using gameplay bricks, and in the last step the user creates the game level by dragging and dropping many 2D and 3D objects. During the process of generating, a fuzzy expert system will guide the users in order, to guarantee the generation of a web-based video game that is both educational and fun. The proposed game generator is a proof of concept able to create puzzle and platformer video games.

The effectiveness of the serious games depends on their ability to transmit the knowledge in a correct way. For this reason we have equipped a serious game with a multi-agents system where each agent has a specific task: the first agent was equipped with a rules engine, this role of the rules engine is to guide players during their game sequence, contrariwise the second agent is able to cluster players according to their performances through the educational data mining algorithms and learning analytics. The main objective of such a system is on the one hand to assist players during the game progression; on the other hand to provide the instructors with a tool for analysis and measurement of students learning level and their progression in the learning process through the video games. By using the system we have noticed an improvement concerning both players' performances and learning outcomes.

The last study was about the development of a serious game composed of two

levels: the first one teaches the dumb children the Arabic sign language through an input device that tracks the hand gestures, the tracked hand gesture will be recognized by using a neural network, and then will be matched by the letter shown on the screen. The second level is in a 3D environment where the player has to find different cubes in order to construct the name of the object shown in the picture displayed on the screen. The serious game has proved its effectiveness, according to the feedback from the players who have tried it.

The research axis of the serious games represents a new trend in both computer science and educational research fields; it knows an exponential development. When other contributions will come soon concerning that axis of research; we will try to enrich it with other new innovative ideas.

4.2 Future works

With de progression that the serious games fields know, there are still many problems to be solved in this area, and also many other axes to be discovered. Below there are some the perspectives envisaged by our work team:

- The improvement of the web-based game generator by including other game genres like RTS, RPG, Adventure, etc.
- Development of others serious games to solve specific issues in the domains of health care, education, etc.
- Prediction of the players performances by using machine learning algorithms like neural network and Bayesian networks.
- Introducing the gamification techniques in classrooms in order to motivate students to learn more, and then compare the results with teaching by using traditional manners.
- Establishment of a multi-agents system that controls the non-player characters to be more adapted for the learning process.

- Development of the mobile learning games because of the advantages that they present.
- Working on the assessment systems in order to evaluate the abilities of the players in an effective way.
- Including other learning analytics techniques in serious games to help the instructors to have a global view on their students performances in order to improve their teaching methods.
- Focused on the use of social networks to share experiences between players.
- The use of the Affective computing in serious games to benefit from its advantages.

There are other perspectives not cited in the list that will be treated in the future, this list shows that the area of research in this direction is very important and promising.

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Appendix A

Tables

Table A.1: Classification and comparison of serious games in business field

Serious Games	Game Objective	Environment	Interactive Tool	Multi-Players	Assessments	Game Genre	Game Engine	Platform	Age Range
InnovNation	Management	2D	Mousse	Yes	Yes	Simulation	Html5	Mobile/Web	>20
SFR (mon entretien dembauche)	Recruitment	3D	Mousse	No	Yes	Simulation	Unity 3D	Web	>20
Moonshield (Thals)	Recruitment	-	-	-	-	Strategy	Flash	Web/ mobile/ PC /IOS	>20
Academy Factor	Recruitment	3D	Mousse	No	Yes	Simulation	-	Web	>20
E-Calling Game	Management	3D	Mousse	Yes	Yes	Strategy- Simulation	Unity 3D	Web	>20
La Fort Durable	Social Security	2D	Mousse	No	Yes	Learning	HTML5	Web/ mobile/ PC /IOS	<14
2020 energy	Social Security	2D	Mousse	No	Yes	Quiz	HTML5	Web/ mobile/ PC /IOS	14 - 20
3D VIRTUAL OPERATING ROOM	Social Security	3D	-	Yes	Yes	Simulation	-	Web	>20
Mecagenius	Management	3D	Mousse	Yes	Yes	Entertainment	-	Web/ mobile/ PC /IOS	14 - 20
PULSE	Social Security	3D	Mousse	No	No	Simulation	-	Web/ mobile/ PC /IOS	14 - 20
Renault	Communication-Marketing	3D	-	No	Yes	Quiz	-	-	>20
Reveal	Recruitment	2D	Mousse	No	Yes	Quiz	Flash	Web	>20
SixSigma	Management	2D	Mousse	No	Yes	Training	Flash	Web	>20
BUSINESS QUEST	Management	2D	Mousse	No	Yes	Simulation	Unity 3D	Web	>20
en-Jeu professional	Recruitment	2D	Mousse	No	No	Training	Flash	Web	>20
CORPORATE TRAINING MARKETS	Management	-	-	-	-	Training	-	-	14 - 20
Sweatshop	Management	2D	Mousse	No	Yes	Strategy	Flash	Web	<14
Star Bank The Game	Management	3D	-	-	-	Training	-	Web	>20
Business	Management	2D	Mousse	No	No	Strategy	Flash	Web	14 - 20
B2P	Communication-Marketing	2D	Mousse, Keyboard	No	No	Advergame	Unity 3D	Web/ mobile/ PC /IOS	>20
Practice Marketing	Communication-Marketing	3D	-	Yes	Yes	Training	-	Web/ mobile/ PC /IOS	>20
Venture Strategy	Communication-Marketing	2D	Mousse, Keyboard	Yes	Yes	Simulation	Flash	Web	14 - 20
SimVenture	Management	2D	Mousse	No	Yes	Simulation	-	PC	>20
Virtual Trader	Management	-	-	-	-	Simulation	-	-	>20
Innov8	Management	3D	Mousse	No	Yes	Quiz	Flash	Web	>14
Working at Height Training	Social Security	3D	Joystick, Keyboard	No	Yes	Training	-	IOS/Android	>20
TeamUp	Management	3D	Keyboard	Yes	Yes	Training	Unreal Development Kit	PC	>14
MSP Challenge	Management	2D	Mousse, Keyboard	Yes	-	Learning	Flash	PC	>20
Hazard Recognition Game	Social Security	3D	Mousse	No	Yes	Training	Unreal Development Kit	PC	>20
HIITS	Communication-Marketing	2D	Mousse	No	Yes	Training	-	PC	>20
McDonald's	Communication-Marketing	-	-	-	-	Learning	-	Web	>20
Spent	Finance	-	-	-	-	Learning	-	-	>14
Show Business, The Economics of Entertainment	Finance	-	-	-	-	Learning	-	-	>14

Table A.3: The fundamental scale for pair-wise comparison

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equal to the objective
3	Moderate importance	Experience and judgment moderately favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very Strong importance	One element is favored very strongly over another its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another of the highest possible order of affirmation
Intensities of 2, 4, 6 and 8 can be used to express intermediate values.		

Table A.2: The overview of various game genres

Action games	Games with a heavy emphasis on a series of actions performed by the player in order to meet a certain set of objectives.
Adventure games	Adventure games place the main emphasis on the story. The objective is normally to gather objects and solve codes and mysteries in order to advance in the game. Players need to use logical problem-solving skills.
Role-playing Games	RPG games with an emphasis on the player's character development and narrative components.
Strategy games	Games characterized by players strategic decisions and interventions to bring the desired outcome
Simulator games	Games intending to recreate an experience of a real word activity in the game world
Puzzle games	This type of game mainly involves solving puzzles. These games do not usually have a story element. They include mathematical and timed problems.

Table A.4: The rules of the fuzzy expert system

R	Educational Gameplay Bricks	Entertaining Gameplay Bricks	Neutral gameplay Bricks	Game Aspect
1	low	low	height	unplayable
2	height	low	low	educational
3	low	height	low	entertaining
4	medium	medium	low	Both entertaining and educational
5	medium	low	medium	educational
6	low	medium	medium	entertaining
7	height	medium	low	Both entertaining and educational
8	medium	height	low	Both entertaining and educational
9	medium	low	height	educational
10	low	medium	height	entertaining
11	medium	medium	medium	Both entertaining and educational
12	medium	low	low	educational
13	low	medium	low	entertaining
14	low	low	medium	unplayable

Table A.5: Messages shown by the system to guide learners during their sequence of serious game

N°	Message
MSG1	You need to focus more to have a good result, you are in the beginning you can do better.
MSG2	Good performance up to now, try to keep the same level of concentration to get the good result.
MSG3	You have to focus more, your result is too bad, and your choices are random.
MSG4	Excellent performance, keep going in the same level.
MSG5	You have to make more effort, and move your hands to collect more objects.
MSG6	The Glass waste is composed of bottles, cups, you have to put those objects in the Green container.
MSG7	The Metal waste is composed of cans, metallic objects, you have to put those objects in the yellow container.
MSG8	The Organic waste is composed of rest of food; you have to put those objects in the brown container.
MSG9	The Trash waste is composed of anything not recyclable like tires, plastic bag. You have to put those objects in the black container.
MSG10	The Paper waste is composed of books, news paper, etc. You have to put those objects in the blue container.
MSG11	The Plastic waste is composed of different plastic objects; you have to put those objects in the red container.
MSG12	You have done a lot of gestures and your percentage of good choices is low, try to focus more during the choice of objects.
MSG13	Excellent performance, you master the subject well.
MSG14	Bad performance, you should revise your course to understand the basics of waste sorting.
MSG15	You have a lot of problems; all of your choices are random, you should revise your course.

Appendix B

Figures

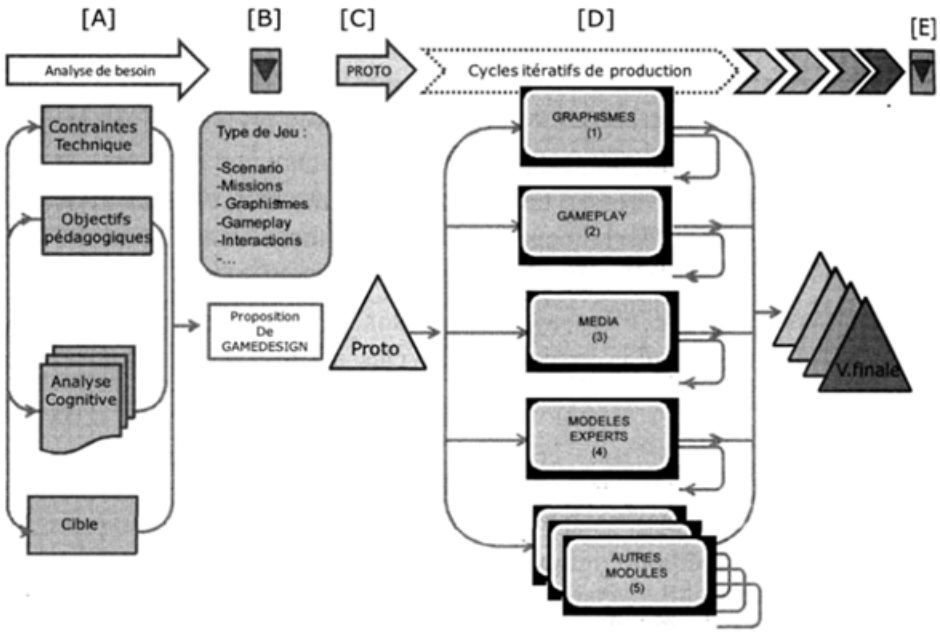

Figure B-1: Industrial model of creating a Serious Game used by KTM.

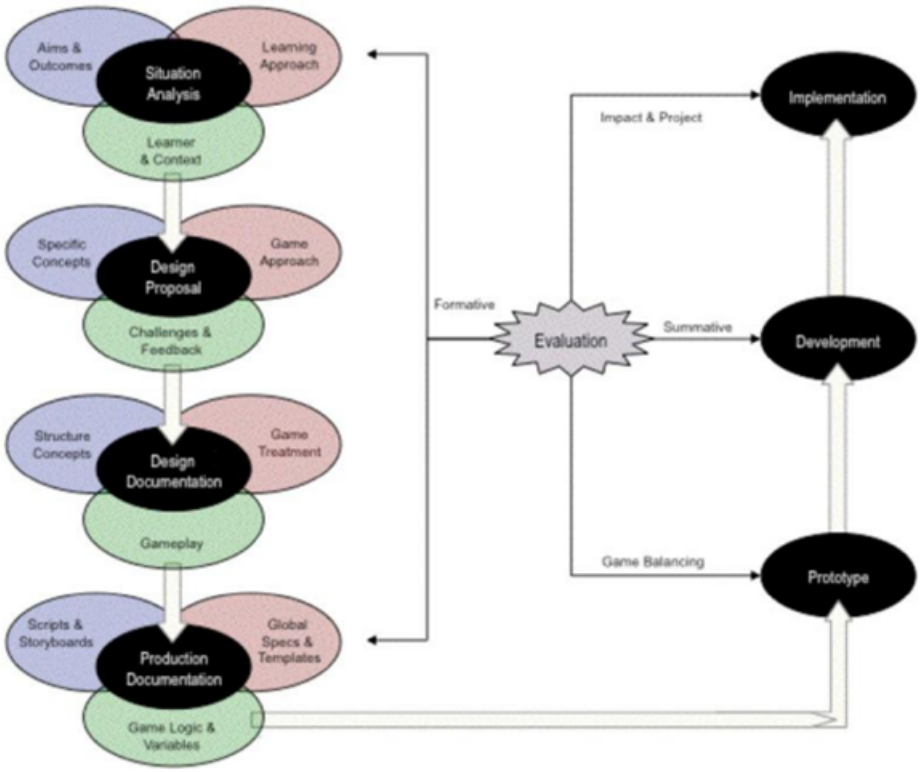

Figure B-2: The DODDLE MODEL proposed by McMahon.

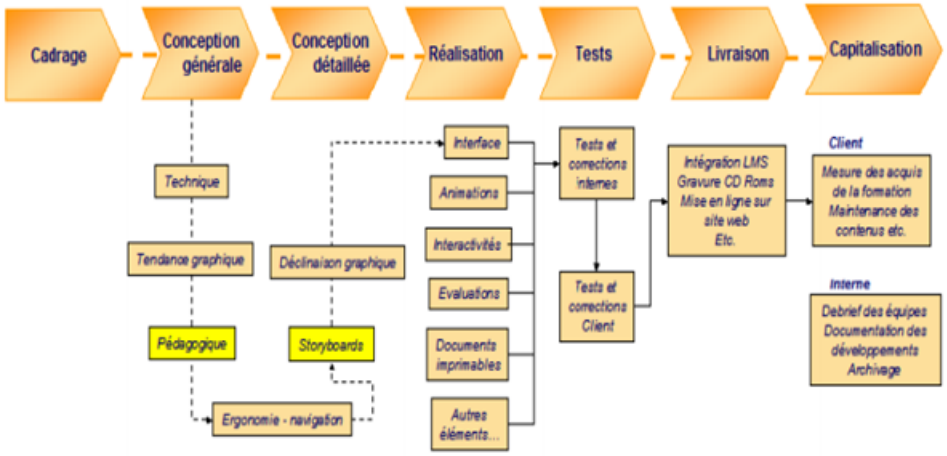

Figure B-3: Industrial model of creating a Serious Game used by Paraschool.

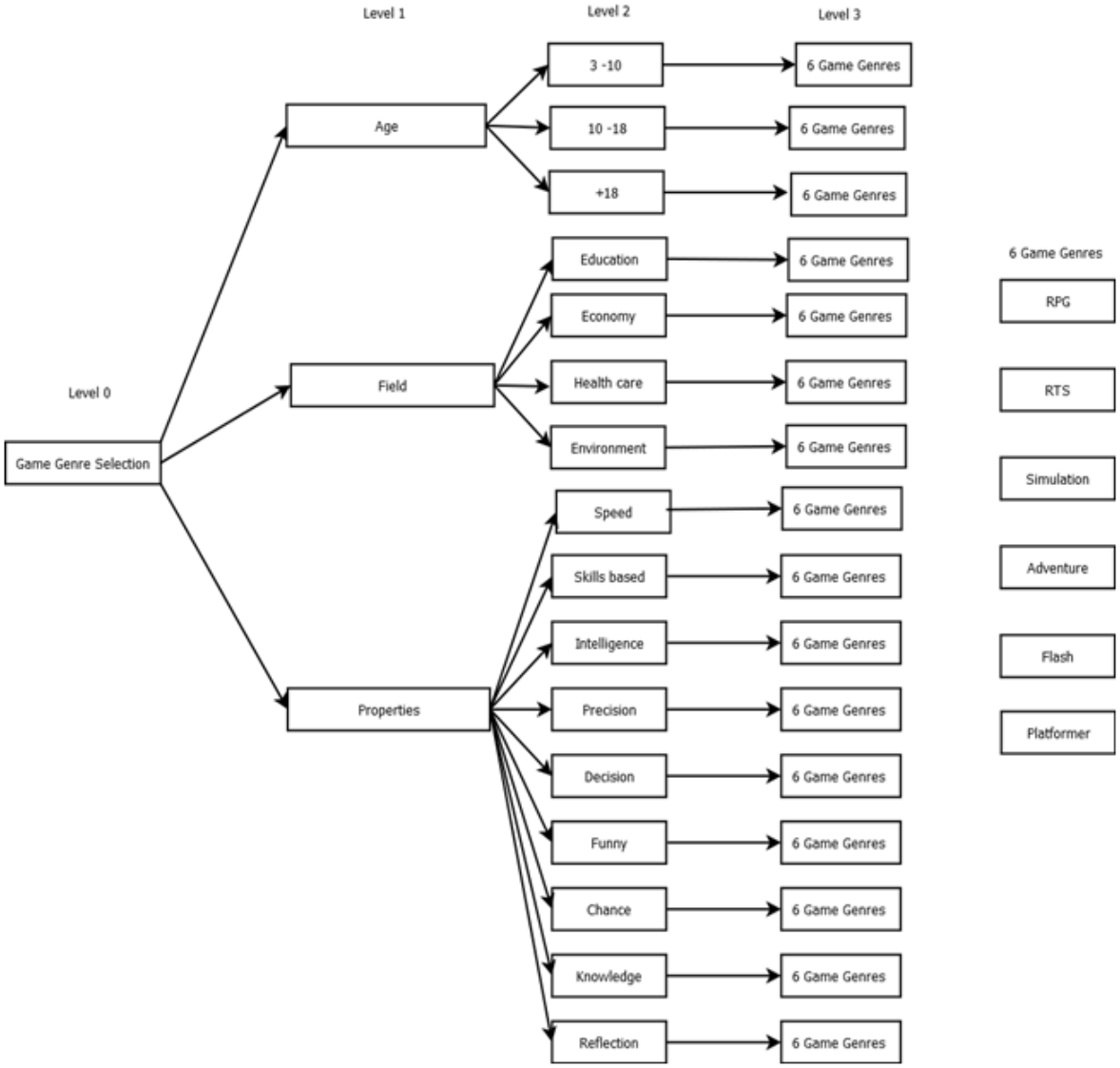

Figure B-4: The AHP hierarchy for game genre selection.

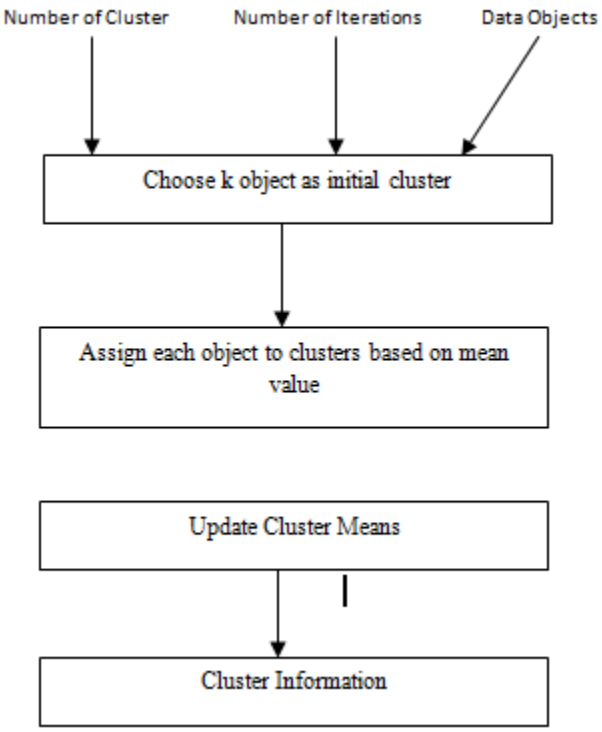

Figure B-5: Flowchart of k-mean algorithm.

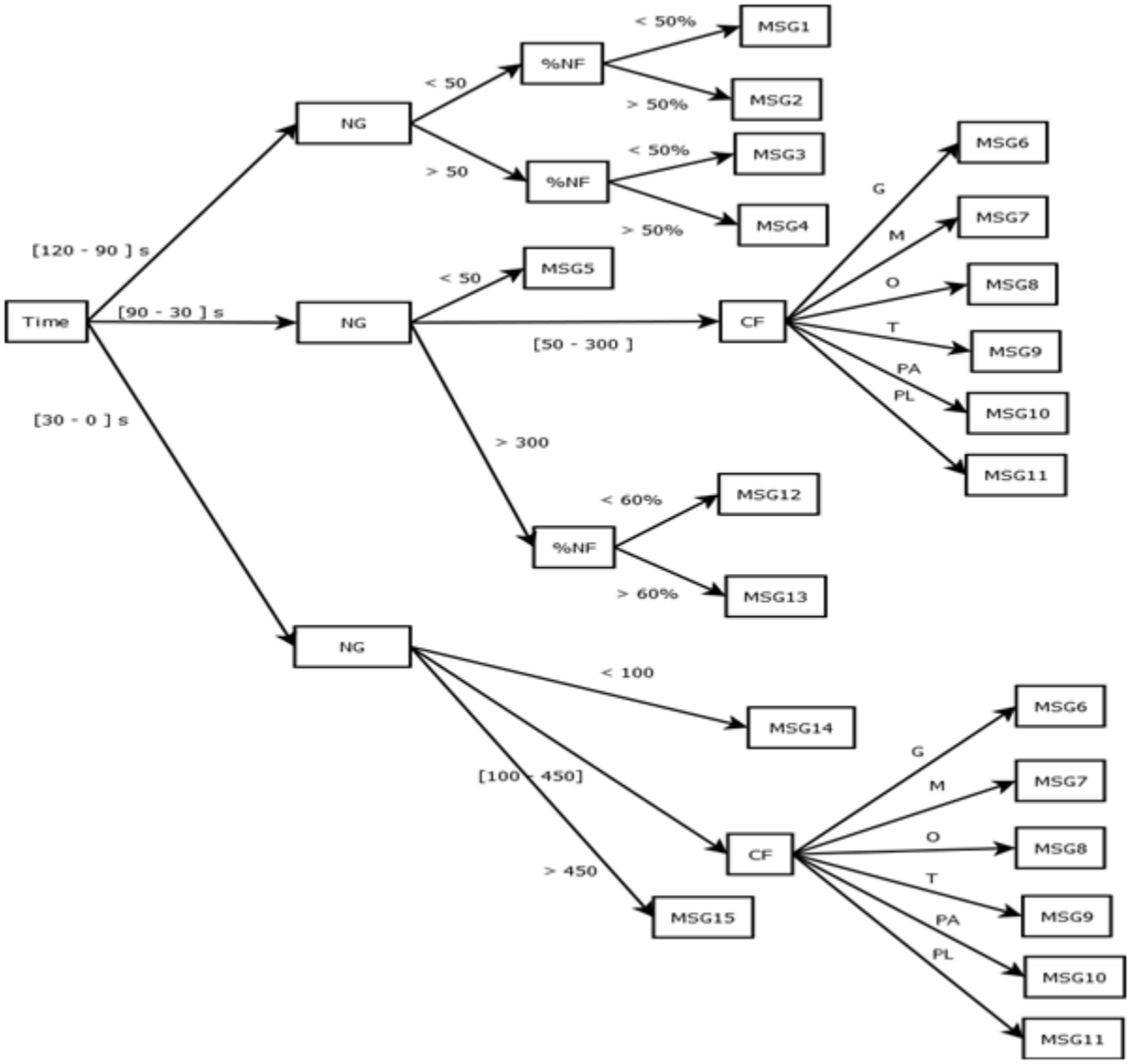

Figure B-6: Scheme represents a rule tree that will guide learners.

Letter / Performed gesture	ا	ب	ت	ث
	0.965	0.324	0.241	0.202
	0.152	0.923	0.752	0.463
	0.123	0.772	0.953	0.632
	0.089	0.652	0.763	0.953

Figure B-7: The values given by neural network concerning the performed gesture and some patterns “four first Arabic letters”.