AN ONTOLOGY – BASED APPROACH TO DESIGN A SERIOUS GAME FOR TEACHER EDUCATION

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF INFORMATICS
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILMENT OF THE REQUIRMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE IN
THE DEPARTMENT OF MODELING AND SIMULATION

June 2015

AN ONTOLOGY – BASED APPROACH TO DESIGN A SERIOUS GAME FOR TEACHER EDUCATION

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ABSTRACT

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June 2015, 74 pages

Increasing popularity of serious games draws many game designers' attention and encourages developers to involve with the field of education. In this respect, an effective serious game design becomes prominent to attain a place in the domain. That is, a successful serious game design should attach importance to educational constituents as well as game design components. On the other hand, merely adding a limited number of game elements into an educational simulation could not lead to a successful serious game. In consideration of related literature, there is an evident need for a comprehensive serious game design methodology, which place equal emphasis on both educational and game design components. In this regard, this thesis aims to propose an ontology-based methodology to design a serious game. In accordance with this purpose, Serious Game Design Ontology (SGDO), specific domain ontology, is proposed to develop serious games of various genres. Additionally, in scope of this thesis, the developed ontology was used in development process of a teacher education serious game called as Game Based Teacher Education System (GATES). In order for developing the SGDO, a variety of educational and instructional theories were surveyed and Gagne's nine events of instructional considered appropriate by reason of its compatibility with video games'

elements. This theory, in addition with main and essential elements of video games composes the concepts of SGDO. Unified Modeling Language (UML) was chosen as the ontology development language. Subsequently, the developed ontology was used in a Game Based Teacher Education System (GATES). For this purpose, the most important constituents about teacher education such as Technological Pedagogical Content Knowledge (TPACK) and classroom management methods were added up to SGDO.

Keywords: Ontology, Serious Game Design, Teacher Education, Classroom management

ÖZ

ÖĞRENCİ ÖĞRETMENLERE SINIFI KONTROL ALTINA ALMAYI ÖĞRETEN CİDDİ BİR OYUN

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Yüksek Lisans, Modelleme ve Simulasyon

Tez Yöneticisi: Prof. Dr. Veysi İşler

Haziran 2015, 74 sayfa

Ciddi oyunlara olan rağbetin artması birçok oyun tasarımcısının dikkatini çekmekte ve onları eğitim alanında çalışmalar yapmak üzere teşvik etmektedir. Bu bağlamda, etkin bir ciddi oyun tasarımı yapabilmek alanda yer edinmenin ön koşulu haline gelmektedir. Bu da demek oluyor ki , başarılı bir ciddi oyun tasarlamak için oyun tasarım elementlerinin yanı sıra eğitsel bileşenlere de eşit oranda önem vermek gerekmektedir. Diğer bir yandan, eğitsel simülasyonlara sınırlı sayıda oyun elementleri eklemek de, başarılı bir ciddi oyun tasarlamak için yeterli olmayacaktır. İlgili alanyazının incelenmesinin sonucunda görülmüştür ki , eğitsel bileşenlere ve oyun tasarım elementlerine eşit oranda önem veren kapsamlı bir ciddi oyun metodolojisine duyulan ihtiyaç açıktır. Bu sebeple, bu tez; ciddi oyun tasarımı kapsamında ontoloji temelli bir metodoloji önermektedir. Bu amaç doğrultusunda, Ciddi Oyun Tasarımı Ontolojisi (SGDO) etki alanına özel bir ontoloji olarak, çeşitli kategorilerde ciddi oyun tasarımına olanak vermektedir. Bunun yanı sıra , bu tez kapsamında tasarlanan ontoloji, öğretmenleri ciddi oyun ve simülasyonlar ile eğitmeyi hedefleyen Karma Gerçeklik Teknoloji ile Öğretmenlerin Eğitilmesi Projesi'nde (GATES) kullanılmıştır. Ciddi Oyun Tasarımı Ontolojisinin (SGDO) geliştirilmesi amacı ile birden çok eğitsel teori incelenmiş ve bilgisayar oyunu elementleri ile gösterdiği uyumluluk sebebiyle, Gagne'nin dokuz adımlı öğrenme kuramının bu tez kapsamında kullanılmasına karar verilmiştir. Bunun yanı sıra, bu teori Ciddi Oyun Tasarımı Ontolojisinin (SGDO) içerdiği konsept ve kavramlar ile de uyumluluk göstermektedir. Unified Modeling Language (UML), ontoloji geliştirme dili olarak seçilmiştir. Sonrasında, tasarlanan ontoloji Karma Gerçeklik Teknoloji ile Öğretmenlerin Eğitilmesi

Projesi'nde (GATES) kullanılmıştır. Son olarak, Teknolojik Pedagojik Alan Bilgisi (TPAB) ve sınıf yönetim bileşenleri de Ciddi Oyun Tasarımı Ontolojisi' ne (SGDO) eklenmiştir.

Anahtar Kelimeler: Ontoloji, Ciddi Oyun, Öğretmen Eğitimi, Sınıf Yönetimi

To my family which, without their supports I wouldn’t be here.

ACKNOWLEDGMENT

This thesis becomes a reality with the kind support and help of many individuals. I would like to extand my deepest gratitude to all of them.

I would like to express my scincere thanks to my advisor Prof. Dr. Veysi İşler for his guidance, support, understanding and encouragement throughout this thesis. I am extremely grateful to him for letting me be a member of GATES project.

I am heartly thanksful to my lovely family that supported me in any respect durig my study. Without their kind help and support I couldn't be here.

Many thanks to my teammates in GATES project, Ceren Ocak, Cansu Tatar, Cenk Köknar and Zeycan Görk for their support, assistance and contribution to my knowledge. Ceren Ocak and Zeycan Görk inteviewed teachers of FATIH Project pilot schools. Some informations from these interview was used to form the hi – tech classroom misbehaviors. The students' and teacher's model factors which were used at the rewarding system was designed by Cenk Köknar. With special thanks to Ceren and Cansu, for the fun we had in our office in the spare time.

I want to give my gratitude to Kianoush Ghasemi and Yaser Mohammadi who have given me their untiring support and precious critique and proofreading.

Also I am very grateful to TÜBİTAK for financial supports through this thesis. This thesis is conducted within the scope of 113E040-GATES Project (Game based Teacher Education System based on 3D Virtual World and Mixed Reality Technology) which is rewarded by BT0101 - FATİH Information Access and Management Systems with 1003 Call Text.

At the end, my appreciations go to my friends and people who helped me in this research.

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CHAPTER 1

INTRODUCTION

With the advancement of the hardware and software technologies applied for video games development, video games themselves improve in different aspects such as mechanics and visual features. They also become more complex and challenging [2]. For many years, video games have been known as an entertainment tool; however, as they became more powerful, they are recognized as a tool not just for entertaining, but also for more serious goals like training, simulating, marketing, and advertisement [3].

Serious Games are a branch of video games in which the main goal is to educate the player as well as providing a fun experience. Serious games are utilized to simulate a wide range of scenarios and let the player experience the situation, learn, and ultimately master some targeted skills. The simulated situations, sometimes are difficult or even impossible to experience in real life due to safety, cost or time factors [4]. These factors make serious games a good choice to use in military, governmental and educational systems.

Increasing popularity of serious games has drawn many game designers' attention and made them enter this field. However, designing an educational game could be very risky because serious games must involve both entertainment and educational components. It has been shown that merely adding a limited number of game elements into an educational simulation could not lead to a successful serious game. One of the common outcomes of playing such games is wasting players' time without adding any new skills. There are different methodologies for designing a serious game in literature. In some, the focus is mostly on educational parts, while others concentrate more on game design elements. Some of the studies attempt to cover both aspects of serious games; however, lack of a comprehensive approach, which focuses equally on both sides, is obvious.

The objective of this thesis is to propose a serious game design approach that covers both educational and game design components. The proposed methodology is made easy to follow and maintain for both human and computer agents by using ontology principals. Heart of serious game design is applied to categorize serious game's components in the

following three groups: theory, content and game design [5]. In the theory part, Gagne's nine events of instruction are used to reach an optimum instruction session inside a serious game [6]. Content indicate the components related to the subject, which the serious game targets to teach. Finally, game design includes all elements related to designing a game. The methodology that is introduced in this thesis has been used in a teacher education serious game development and will be explained in detail.

Game-based Teacher Education System (GATES) [7] is an in progress serious game, which its main goal is to train teachers in order to create easier and more efficient teaching processes using technology equipment in their classrooms. GATES mainly targets the mathematics teachers in sixth and seventh grades. The primary intention of developing GATES is to train the teachers who start teaching in a technological classroom, an environment that is unfamiliar for some teachers. Also this project provides training opportunities for Turkish teachers so that they can feel comfortable while teaching in FATIH project classrooms [8], GATES could be played by any teacher who needs some training about classroom management skills in a hi–tech classroom. FATIH project is a newly established project in Turkey that started to integrate classrooms with technology to build more appealing learning experiences for the learners.

In GATES, the teacher tries to manage a virtual classroom. His/her mission is to teach a topic in mathematics by using technological equipment e.g. smart board, tablet, etc. while trying to keep the disruption in minimum level. The game would send feedbacks to the player so he/she could understand which of the actions are right or wrong.

The feedback system developed for GATES, which is a part of this thesis, is a rewarding system that in addition to helping teachers understand their wrong choices, makes the game more challenging and enjoyable. Player's actions are scored and categorized into three groups: teaching methods, misbehavior dealing methods and use of the technical equipment. For each group, there is a predefined set of rules, which indicates the best choice for each situation. The system uses these rules to give positive or negative points to the player according to their choices.

One of the most important goals of GATES is to know and apply the classroom managing strategies and work with technical equipment in an efficient way. It is assumed that teachers know the best methods to teach a topic and control the classroom in advance. Hence, to evaluate players' level of knowledge, Technological, Pedagogical and Content Knowledge (TPACK) framework was applied. This framework was used to assess player's actions and to define their weaknesses. After defining the feedback rules, they were added to the developed ontology. In the following chapters, all of these components are presented in detail.

The outline of the thesis is as follows:

- Chapter 2 provides a background about the issues that were significant in development of the suggested designing ology and developing its ontology. In this chapter, some fundamental concepts about classroom management, TPACK, instructional theory, serious games, Ontology, and UML are explained.

- Chapter 3 includes some related works about the topics mentioned in the previous chapter.

- Chapter 4 contains our proposed approach for designing serious games and the methodology used to develop the Ontology system.

- Chapter 5 provides a comparison between the proposed method and the methodologies available in literature. A conclusion part follows.

CHAPTER 2

BACKGROUND

In this chapter, a brief explanation of classroom management is given. This topic followed by Technological Pedagogical Content Knowledge (TPACK)'s definition and a summary of International Society for Technology in Education (ISTE) standards. These two subjects together provide a general view of the skills and capabilities that GATES targets to teach its player. The information gathered about these two subjects provides the main data, used to develop GATES' feedback system, which will be explained in detail in the next chapters. This chapter continues by outlining instructional theories. Then an overview of serious games is provided. At last, a definition of ontology and tools for developing it is given.

2.1. CLASSROOM MANAGEMENT

To have a more efficient teaching – learning experience, teacher is not the only effective factor. Classroom atmosphere also plays a significant role in the learning process. Besides, the students are also responsible for contribution in building a pleasant environment to have a mutual relation and respect. Classroom management methods could help teachers to achieve this goal; moreover, these strategies are generally teachable and can be gained from personal classroom experiences.

Classroom management methods consist of both teaching and misbehavior dealing methods. In traditional methods, the classroom environment was mostly competition-oriented; however, modern methods aim to have a more cooperative classroom [9]. These modern teaching methods also are affected by entering the technologic equipment into the classrooms. The aim of developing the GATES serious game is to accustom teachers to new methods of classroom management in technological classrooms. Besides, not only did the methods for teaching change, but also the incorporation of technology in classrooms cause teachers to face new misbehaviors. GATES tries to simulate these situations and asks the teachers (players) to choose the best action in each situation.

2.2. TPACK

As previously mentioned, the aim of using technology in a classroom is mainly to ease the learning process for students. Despite that, the way teachers integrate technology to their teaching method is critical. TPACK, proposed by Mishra and Koehler [12], is a framework, which focuses on more efficient methods of using the technology in teaching process. TPACK provides the skills a teacher must own to teach the specified content by integrating technology to pedagogy methods [12]. According to Mishra and Koehler, TPACK framework demonstrates the connection between content knowledge (CK), pedagogy knowledge (PK) and technology knowledge (TK). They believe, all three components are essential to establish a good method of teaching. However, it should be kept in mind not to treat them as three separate parts. Figure 2.1, which is a graphical representation of TPACK and its components, was obtained from [12].

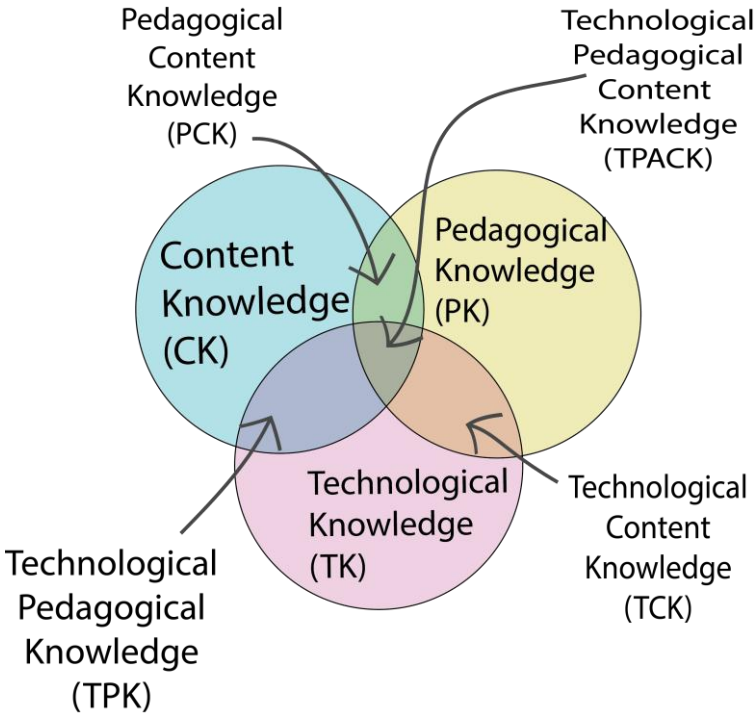

Figure 2.1: Graphic representation of Mishra and Coehler TPACK.

ISTE also has developed the standards providing the necessary skills and knowledge, teachers should own to be able to teach in technological environments [13]. These standards are summarized and represented as follows:

1) **Facilitate and inspire student learning and creativity.**

   Teachers are encouraged to use their knowledge of teaching and technology, to improve student's learning and creativity, both, in face – to – face and virtual

environment. Teachers engage students in exploring real world issues and solving problems using digital tools and resources.

2) **Design and develop digital age learning experiences and assessments.**

Teachers aim to develop the student's knowledge, skills and attitudes. Technology – enriched learning enables students to pursue their individual curiosities and become active participants in their own education goals.

3) **Model digital age work and learning.**

Teachers demonstrate fluency in technology system and transfer of current knowledge to new technologies and situations. They communicate and collaborate with students, parents and community members using digital tools and resources to support students' success and innovation.

4) **Promote and model digital citizenship and responsibility.**

Teachers teach safe, legal and ethical use of digital information and technology, including respect for copyright, intellectual property and appropriate documentation of sources. Students develop their cultural understanding and global awareness as well.

5) **Engage in professional growth and leadership.**

Teachers continuously improve their professional practice and demonstrate the effective use of digital tools and resources. They contribute to the effectiveness, vitality and self – renewal by participating in local and global learning communities.

2.3 INSTRUCTIONAL THEORY

In the field of education, the quality of teaching – learning process is very essential. Hence, a large number of studies, theories and models attempted to provide methods that cause an increase in quality of instruction. Instructional Theory, as one of the most well – known educational theories, concentrates on providing essential principals for instruction. This theory can be used to design a better teaching plan. An increment in quality of instructor's performance causes advancements in students' learning and development. This theory, not only helps in the method taught by instructor, but it also gives guidance in choosing appropriate lesson materials during whole teaching session [6], [14].

Robert Gagne´ proposed one of the theories that have been largely used for instruction. His nine events of instruction indicate different steps of learning that leads to a more effective and optimal lesson session. The list below indicates these nine events [6].

1. Gain attention.
2. Informing learners of the objective.
3. Stimulating recall of prior learning.
4. Presenting the content.
5. Providing learning guidance.
6. Eliciting performance.

7. Providing feedback.
8. Assessing performance.
9. Enhancing retention and transfer.

Event 1: Gain attention: Before starting to teach, learners should feel ready to receive new information. Hence, motivating the students should be the starting point of each instruction.

Event 2: Informing learners of the objective: Informing about learning goals before lesson starts affects students' motivation. They gain expectancy about what they will gain.

Event 3: Stimulating recall of prior learning: New information which students are going to learn is related to their previous skills and knowledge. However, learners sometimes have trouble with recalling them while learning new skills. In these situations, it is teachers' responsibility to help learners to link their previous knowledge with the skills they are going to learn.

Event 4: Presenting the stimulus: In this event, instructor presents the essential elements needed for learning the new tasks and skills in order to reach the desired outcome.

Event 5: Providing learning guidance: Similar to the previous event, this one also depends on the desired outcome. Level of the help and guidance the learners receive depends on the skill level of students, duration of instruction session and the defined goals.

Event 6: Eliciting performance: In this event, it is assumed that the teaching process has reached to its end and now it is time to provide opportunities to the learners to perform what they have learnt without any penalty. Answering a basic and important question could be an example for this event.

Event 7: Providing feedback: After students perform the skills they have gained recently, instructor gives informative feedbacks. The feedbacks should indicate the accuracy of the given answer. In the case that the answer is wrong, the provided feedback should help the student to find the right answer to the question.

Event 8: Assessing performance: Before the student learns any newly taught skill properly, he/she should perform it and corrections must be made for the wrong answers frequently. Therefore, the teacher needs to evaluate and assess student's performance by taking tests, projects, etc.

Event 9: Enhancing retention and transfer: In the last event, the students should use their own knowledge and beliefs in different situations to make decision. In an instructional session this situation is created by discussions, role-playing games or computer – based simulations.

These nine events of Gagne´ are commonly used to organize lesson plans. Integrating the same events in an instruction would have similar results regardless of whether they have been used by a teacher in a classroom or have been modeled in a computer – based tutorial. In an instruction, according to Gagne´, using more events lead to students' boredom, on the other hand omitting one or some event results in instruction failure.

Besides, although following these events in the proposed order would result in a better outcome, it is not a necessity [6].

Next part provides a brief definition of serious games- the games that aim to teach and are used for training.

2.4. SERIOUS GAMES

In modern day, technology encompasses more aspects of everyone's life. Education, an essential part of our lives, is not an exception. How the education system combines with technology has been a highly researched area. Researchers attempt to find better ways of incorporating old education system with modern technologies to ease the learning process and also making it more engaging and pleasant. One of these solutions is the use of video games in the learning process. Considering that learning through playing is not a new topic; people started learning about their environment through playing since they were toddlers [15]. They also use playing as a way to communicate with people and their surroundings. Moreover, human beings are not the only group of living creatures who learns through playing – animals also act in same way. Lions do not learn how to hunt using theories, facts, and rules, but instead learn through simulation and playing [4].

Video Games are one of the efficient procedures of unifying education and play. Three decades ago they entered people's lives as the youngest member of the entertainment family. However, video games are not the least important member of the family anymore and they changed the entertainment culture. Video games have had a fast growth and after only a couple of decades after their advent, they have entered almost everyone's life regardless of their cultures, genders and age groups. This aspect of videogames attracts researchers and educators to use this power to reach their goal, i.e. a more pleasant learning process. Their attempts resulted in developing a new genre of video games called "Serious Games".

The first thing, which attracts attention, is the "Serious Game" term itself. The name formed from two words "Serious" and "Games", which have two opposite meanings [16], [15]. "Games" are defined as an activity done for pleasure, fun, and entertainment. Nevertheless, it follows world "Serious" which is the antithesis of fun and entertainment. However, "serious games" are games that have an educating goal instead of an entertaining one [17]. In other words, researchers, educators and game developers used the fun factor of the video games as a tool for making the old education system more pleasant. Serious games actually are not a new field. They are being used in education even before the birth of video games. Playing cards, board games, educating TV shows and educating comic books [15] are some instances of the old generation of "serious games" equivalent. Overall, the new generation of serious games refers to a type of video games whose main goal is not to entertain, but to educate [16].

The education system is not the only field that gets to use serious games, military and defense, healthcare, advertisement and economics, city and energy planning are some of the other costumers of serious games [18]. According to a research done in 2010, the

global market of serious games was about 1.5 billion € [16], which is supposed to rise due to the increasing attention.

In the survey of the history of new generation of serious games, this question occurs that what is the most popular serious game. According to Sawyer [4], America's Army video game has a great level of popularity among the people. America's Army, in some aspects, was one of the leading games combining fun and teaching potential. In 2002, a staff sergeant played America's Army for the first time and planned to use it as a learning tool for new recruits. Some part of his training, which was difficult to practice in real life, was performed in the virtual world of America's Army. The soldiers, however, were not the only group trained by America's Army, but so were children. In spite of parents' growing complaints about the game and its negative effects on children, they also informed the developer group that their children now know a great deal about the army thanks to the game [18].

This example explains the above-mentioned power of video games and their potential to build a pleasant environment for learning. It has been seen that serious games not only do not omit the fun factor of the video games, but also use it to empower the serious games. A good serious game is an engaging and educating one. If the game motivates the player, it catches players' attention and leads to an implicit learning [19]. Parents' comments about America's Army indicated the implicit learning of the children who played the game. The researchers and developers attempt to develop a serious game that helps the students learn implicitly. When considering a serious game's attributes, it is comprehended that they could fit the flow theory [19], [20].

- Player encounters challenges in the same level of his skills level.
- When mastering newly learned skills he would be leveled up.
- There are defined goals that the player tries to reach.
- Player receives appropriate feedback according to her/his actions.

To compare serious games and classroom's environment according to the process of teaching a new skill it is obvious that these two methods are not equal in gaining the same new skills. Serious games require interactivity; however, the desired level of interactivity is not available in a classroom for all of students all the time. The other difference could be the feedback and its frequency. In the classroom the teacher is not able to get feedbacks for each performance of students due to time limitations. However, in serious games, like other types of video games, the player receives almost immediate feedback related to his each action. These feedbacks could inform the player about his/her skills [17].

Educating is a combination of training a subject and assessing the learner's performance. Exams are one of the choices to evaluating the learners. These exams are modeled as different challenges in serious games [17]. This characteristic is not limited to the serious games, and is observed in any entertainment video game. With a closer look at the entertainment video games, one can easily see that all video games are a serious game in some level. They have tutorial parts that teach the players how to play the game, and they have a scoring system that evaluates the player's skill. The result of this evaluation indicates whether the player passed or failed and whether has to repeat this level. It may be said that the main difference between video games and serious games are their primary goals: one is meant to entertain while the other aims to educate [17].

Learning while experiencing the situation results in a better understanding of the topic, hence leading to a better learning [4]. In serious games, the trainee experiences the situation, learns from it and uses his newly learned skills to advance to the next level. Serious games provide the player with situations and experiences that are impossible to encounter in real life due to safety issues, time and cost [21]. In addition, the trainee could replay the situation as many times as he wants until he masters his skills. Besides, the wrong actions performed by the trainee in virtual world of serious games would not affect anything in real life. A pilot, who just graduated from the school, will not fly an airplane full of passengers and risk their life since he needs more practice. Additionally a medical student cannot enter a surgery room and start operating on a patient to practice what he just learned in class [10]. There is also a serious game about fire in a forest in Texas that teaches how to firefight [17].

According to [22], designing a serious game is not as simple as putting educational concepts in a video game in order for the game to be entertaining enough to engage the player. In [23], Moreno – Ger et al discoursed about various outcomes of education and video games compound. They believed that educational game – like environments, are at one end of this spectrum and entertaining video game are on the other end. Serious games are in the middle of education and entertainment. They later explain each type briefly: 1) edutainment that contain the edutaining components with a little playability. 2) Entertaining games that their goal isn't educating but they could be used in classrooms for training students. 3) Serious games that designed for a specific purpose and have both educational and fun elements. What is important in choosing a commercial video game to be used in a classroom is the genre of the chosen game. Different genres are applicable for different skills. For example, card games are good for pattern recognition; arcade games are helpful for increasing respond time; adventure games could be a good choice for problem solving; action games, on the other hand, are rarely preferred to be used as an educating game. Some examples of games, which have educational aspects, are: SimCity, The Sims, Civilization, and Age of Empires. According to [4], even "Grand Theft Auto" can be used to learn morality and ethics. Other issues to consider while choosing a commercial game would be the value of presenting the subject matter, the subject related information, which is not provided in the game, and the point of view game has about the subject. Any wrong choice could be misleading [4].

2.5. ONTOLOGY

The last part of background review, will discuss the meaning of ontology, its attributes and usage.

When searching for the meaning of ontology the results and definitions could differ from each other. Ontology is a word obtained by AI researches from philosophy in early 1990s [24]. In philosophy, ontology is the study of the world, reality or existence and the constitutive elements of it. Many years after defining ontology for the first time, ontology entered to the field of computer and knowledge management. In computer science, ontology refers to a model, which provides a common understanding between humans and software agents about a specific domain. The common understanding provided by ontology makes it noticeable by the researchers of different fields. Ontology engineers

visualize and formalize a domain's components and their relations with other components.

It is stated that providing a common understanding of domain both for human and agents makes it important in different fields. According to [1] ,a shared domain understanding is not the only reason of developing ontologies as they make domain information reusable. Once an ontology is developed for a specific domain, it can be used by whom are interested to get an understanding of a system. In addition, if a more sophisticated ontology in the same domain is going to be developed, the current ontology could be a part of it and there is no need to design these parts from scratch. Developing ontologies makes analyzing field information plain, give a good understanding about the information and provide the definition used in an area to new users. Separation of domain knowledge and operational knowledge is another important factor. Configuration of a product could be modeled as an ontology and this could be used for developing different products. Making assumptions about a scope more clear is the most significant advantage of developing ontologies. Ontologies aid to control and update the assumption of the domain. When some parts of the system change, it is easier to track their change on the ontology.

Ontologies are generally categorized based on the language they use and the domain they model. The four groups mentioned in following survey are organized according to the language they use [25]. Information ontologies are composed of diagrams to explain development of a project to humans. These ontologies are formal and schematic diagrams that are mostly developed in the design level of evolution of a project. Revision simplicity is a major characteristic of this group. Some domains that use information ontologies are architectural and urban design. Mind Map is an example for the tools used in developing these ontologies. It uses a tree structure to model information.

Linguistic/Terminological ontologies are used as dictionaries and vocabulary databases. The mentioned ontologies define the vocabularies of a certain domain, which are categorized by a group of users. Urban Development Data Base Thesaurus (URBAMENT) and General Multilingual Environmental Thesaurus (GEMET) developed with the help of linguistic ontologies. Simple Knowledge Organization System (SKOS) and Resource Description Framework (RDF) are also some examples of the languages used to develop the ontologies belong to this group.

Software ontologies are another group of ontologies, which their main purpose is storing, and manipulating data with the promise of data consistency. In software developments, these ontologies are usually the best choice. Utilizing the languages used in software and database designing develops software ontologies. Entity – Relationship Model Language, Object Model Language are the two languages used to define these ontologies. However, the best choice to develop software ontologies is Unified Modeling Language (UML). Industry Foundation Classes (IFC) model which targets the interoperability between construction sector software is a good example of these ontologies.

Formal ontologies use formal logic, strict rules and explicit semantics to define the concepts and their relations. In formal ontologies the vocabulary used to define concepts are symbols that help the user work with the logical formulas. Knowledge Bases (KBs) are formalized systems that use logical formulas to accept definitions of concepts. Protégé is a typical tool for developing knowledge bases. Description Logic (DL), Conceptual Graph (CG), web Ontology Language (OWL) are a number of languages adapted to model formal ontologies. W3C recommended the latter one. CoBra ontology that aims to simplify pervasive computing environment, developed using OWL.

The second categorization of ontologies relates to their scope. According to [25] in this classification, ontologies are divided to five groups. Local/Application ontologies model one's peephole of a specific field. Domain ontologies, on the other hand, only are used to model areas with specific standpoints that indicate how a group of users could visualize different facts of the domain. Combination of a couple of domain ontologies results in creation of a new group of ontologies named core References ontologies. In other words, core reference ontologies are domain ontologies with several viewpoints of user group. General ontologies unlike the mentioned ontologies do not encompass specific information. They model general information. Foundational/ top-level/ upper ontologies, which are generic ontologies with definition of basic concepts, utilize in different domains.

There are different methodologies to develop ontologies. According to [1] there are some significant principals about developing an ontology that one would refer to them consistently. They mentioned that there are several correct methodologies to model an ontology and not just one correct approach. The correct approach depends on the model developer wants to design. The process of designing is a repetitive procedure. The later rule suggests that choosing concepts for ontology should be related to real objects. In ontologies, classes indicate the main concepts. These classes could own some subclasses, which present more-detailed concepts of the domain. Properties (slot) are indicators of class attributes such as specific samples of classes. To develop ontology for a domain, all the classes and subclasses have to be defined and their taxonomy should be designed. Afterwards, slots and their acceptable values have to be clarified. Defining classes' instance results in creation of knowledge bases. The above – mentioned process is an outline of the ontology development process that will be described in more detail in the following chapters. At last, a suitable tool should be chosen to complete the design procedure. Next part provides information about UML the chosen language to model GATES' ontology is explained in more details.

Next part will focus on Unified Modeling Language (UML), which is one of the languages to develop ontologies.

2.6. UNIFIED MODELING LANGUAGE (UML)

Unified Modeling Language (UML) is a visual language, which is a popular tool for software and application specifying and modeling. It is not just limited to software engineering and is used to design and model information about a specific field, like

medical electronics, telephony, robotics, game design, etc. [26]. It not only makes the designing process easier, but also makes all other phases of developing a system like analysis phase more painless [27].

UML provides a set of diagrams that could be used to formalize and design a system in a determined domain. Class diagram, one of the diagrams provided by UML, is used to model systems components and their relations. The objects with similarities in the system form unique class and their similarities and attributes should be defined as class attributes and the functions of these objects should be listed as class functions. At the end, the relationship of classes of the system should be modeled [28]. All of these features present brief information about the system.

CHAPTER 3

RELATED WORKS

At this point some related works about the topics provided in the previous chapter are mentioned. First, some works about classroom managment methods are introduced. Then a couple of studies about TPACK are reviewed. Afterwards, various studies about serious game design are clarified. Later, some of the most well-known serious games about teacher education are explained. Then some works about serious games' ontologies and educational ontologies are mentioned. At the end, some works that uses UML to develope ontologies are listed.

3.1. CLASSROOM MANAGEMENT

In "Management of teaching and class control"[9] Ayten Iflazoglu Saban seeks to find the actions taken by teachers to manage their classrooms. Eight fifth grade teachers in Adana – Turkey were observed to provide samples for this study. Saban mentioned in his research that having a good lesson plan would decrease the disruption. This lesson plan should be prepared according to the needs and skills of the students. If the teacher chooses the classroom activities appropriately, there will be a significant decrease in wasted time in classroom. According to him, having a well-designed lesson plan will help the teacher in both, teaching and classroom management. Furthermore, it will also keep the students busy and decrease the chance of emerging problems and disruptions in the classroom.

Preparing a lesson plan is one of the tasks the player should be able to do in GATES. The player will control the classroom and teach the subject according to her/his prepared lesson plan. In GATES, the player will gain points based on her/his preparations of the lesson plan. In another study, called "Teachers and Students Perceptions towards teachers classroom management applications in primary schools" [11], Feray Konti investigates the management methods used in primary schools. Konti mentioned that, "teacher is the most significant factor at student learning" [11]. In her opinion, establishing a close and effectual relationship with students is essential for teachers. Konti expresses that to have a better teaching section, the teacher must have a suitable classroom management method, which is obtained by experience. Konti also suggests that managing a classroom in a

proper manner does not guarantee vanishing of misbehaviors. A classroom is a set of students with multiple characteristics, backgrounds and expectations causing them acting differently. For instance, while some students understand the presented information, the other students struggle to follow the same information. Konti concludes that teachers need to be taught about classroom management.

As previously mentioned, the aim of GATES is to train the teachers about classroom management methods, especially in hi – tech classrooms. GATES helps teachers to prepare an efficient lesson plan for each topic; but it also reduces disruptions by choosing more efficient methods of dealing with students' misbehaviors. Therefore, GATES has a set of predefined misbehaviors that will occur unrelated to the player's performance. In conclusion, a good teacher cannot guarantee an undisruptive classroom, a fact, obvious for almost all teachers. In her research "Teacher perceptions of classroom management and problematic behaviors in primary schools" [29], Semra Demir investigates the misbehaviors of students, the route of these behaviors, and the methods to deal with them. For this study, 18 teachers in Kayseri – Turkey participated. Demir states that misbehaviors have negative effects on pupils' education and are a major cause of time waste. Some of the most common misbehaviors are that students: come without supplies, come late to class, call out and have impolite manners towards the teacher and other students. They also express different reasons for this kind of behaviors such as: family, lifestyle, society, friends, Internet and TV. The teachers had taken different approaches for preventing unwanted behaviors in the classrooms. Some of them suggest that being prepared for that day's topic will reduce the misbehaviors of the pupils. Some mentioned that the level of teacher-student relationship has an effect on behavior of students. Besides, using body language also is effective. The misbehaviors and methods to deal with them that mentioned by the teachers in this study were just a small collection used by GATES to simulate a virtual classroom. Weinstein in some chapters of her books "Elementary classroom management Lessons from Research, Practice" and "Secondary Classroom Management Lessons from Research and Practice" depicts the misbehaviors that occur frequently in elementary and secondary classrooms, as well as introducing the methods of dealing with them. This information is gathered by witnessing classrooms of five teachers for several months. Weinstein categorized the misbehaviors occurred in these classrooms, and then summarized the methods that these five teachers used to confront with these problematic behaviors. In these books, there are four groups of misbehaviors and dealing methods. These four groups are: Minor Misbehaviors, More Serious Misbehaviors, Chronic Misbehaviors and Thorny Misbehaviors. These teachers choose different methods to cope with misbehaviors; however, all of them agree in one manner; to speak to misbehaved pupil calmly and privately [30], [31].

In GATES, the majority of these misbehaviors are used. However, since the range of the students' age in the serious game is about 12 – 14, secondary classrooms misbehaviors are more dominant. Furthermore, thorny misbehaviors that were not suitable with GATES classrooms due to cultural differences were omitted. Yet, another group of problematic behaviors, named "Hi – Tech Classrooms' Misbehaviors", was added. The dealing methods used in GATES are also similar to the ones mentioned in these two books.

Studies, which examine teachers' TPACK skills in technological classrooms, will be discussed in the next part.

3.2. TPACK

Different studies done related to Mishra and Koehler proposed TPACK. In one of these studies, an online survey was developed in which the participant teachers asked to answer some questions about their TPACK skills; they asked the participants to scale their skills from 1(poor) to 5(excellent). Questions like "My ability to use technological representations (i.e. multimedia, visual demonstrations, etc.) to demonstrate specific concepts in my content area)" or "My ability to use technology to predict students' skill/understanding of a particular topic" which indicates the TK and TPK of the teachers were asked in the online survey. In this study the result indictaed that the theorically proposed seven domains of TPACK may not exit in practice [32]. In other studies, researchers tried to get use of TPACK in more specific education fields like science and mathematics. According to L. Niess et al. [33] in 2008, most of the teachers had difficulties in integrating technology in their mathematics instructions. Adopting technology into their teaching plans was not as fast as the technology improvement [33]. However, at 2008 for ISTE questioned teachers to pay attention to the skills student would need in the technologic world around them. In this study, they tried to show the importance of using technology in mathematics subjects. They interviewed a teacher who started to use different applications while teaching technology. L. Niess et al. believe that the TPACK mathematics standards encourage the teachers to integrate technological applications and tools into their curriculum; however, they do not show the way of doing it [33]. Another study was done about the affect of using interactive whiteboard (IW) in teachers TPACK in Taiwan [34]. Jang and Tsai in this study analyzed the elementry school mathematics teachers' TPACK knowledge in classrooms with IWs. They prepared a questionarie to analyse teachers' TPACK skills. "I use interactive whiteboards (technology) into teaching activities.", "I use interactive whiteboards (technology) into teaching activities." and "I use appropriate instructional tools such as pictures and models to explain the concept of the subject." are some of these questions the survey uses to determine the level of TK, TPK and PK of Taiwanian teachers [34]. The result of this study indicates a notable difference in TPACK knowledge between the group of teachers who used IW in their teaching and the group of who did not.

3.3. DESIGN METHODOLOGIES OF SERIOUS GAMES

In previous chapters, importance of having a good approach to develope a serious game was disscused. To develop a prospering serious game always an acceptable portion of entertainment and education must be involved [3]. The developer team of a serious gamet should have experts in both game developing and education areas. The following studies attempt to make a balance between different components of the serious game and puroposed a design approach.

In his study, Winn [5] mentioned about the similarities between serious game design and TPACK. he indicated the overlap of these two concepts. According to him, the main components of designing serious game are theory, content and game design which overlap pedagogy, content and knowledge which was proposed in Mishra and Coehler's TPACK. The Design, Play, Experience (DPE) framework which was proposed in this study, was created by extending the Mechanics, Dynamics and Aesthetics (MDA) framework designed by LeBlanc. MDA framework is used in entertainment game design. DPE framework indicates the relation of the designer and the player in an iterative process. Designer designs a game which the player plays. This process results in player experience that affects the design of game. Figure 3.1 outlines different components of this framework. In this framework, the designer is able to control the design part. He stated that his framework can be used by all individuals intended to analyze any serious game.

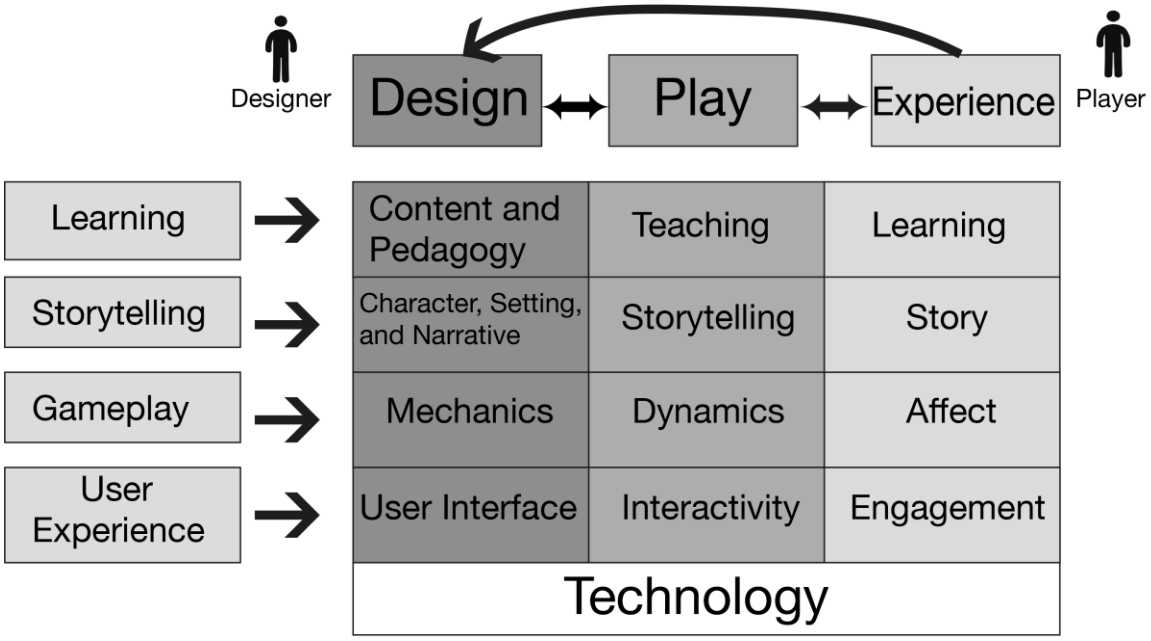

Figure 3.1: DPE framework proposed by Winn [5].

Gunter et al [22] believe that not all serious games are affective since either game chosen to use in classrooms is not suitable or the educational concepts are added to games inappropriately with the idea that game would motivate the player to learn. This problem leads them to develop a serious game design paradigm which pays attention to both educational and entertainment factors of serious games. In their study, they stated that a serious game should be designed according to learning theories. For this purpose, they made use of theories of three well – known educators: Robert Gagne´, Benjamin Bloom and Keller's ARCS model. It is discussed that to make a successful serious game, the designer should know the focus of the game and has knowledge about both educational and game design aspects from the beginning of the design process. Gunter et al state that instructional theories and serious games are similar and this will ease using of instructional theories in serious game design. The Relevance Engagement Translation

Assimilation Immersion Naturalization (RETAIN), a design model for serious games, is the result of Gunter et al study. According to the authors, seven of nine events of Gagne´ have equivalents in serious game design. For developing RETAIN, nine events of Gagne´, Keller's ARCS model are used and their equivalent components in serious games are proposed. These components are indicated in Table 3.1. Gunter et al. propose that a better training would be achieved by using these principles.

Table 3.1 Gagne's Events Of Instruction, Keller's Arcs Model, Common Game Design Elements [22].

Gagne's Nine Events	Keller's ARCS Model	Common Game Elements
Gain Attention	Attention	Scenario exposition
Inform of Objectives		Problem Setup
Stimulate Recall	Relevance	*No existing game analog*
Present Stimulus/ Lesson		Offer Challenge / Choice
Provide Learner Guidance	Conficence / Challenge	Provide Direction
Elicit Performance		Elicit Action / Decision
Provide Feedback	Satisfaction / Success	Discernable Outcome
Assess Performance		Success / Failure screens
Retention and Transfer		*No existing game analog*

Morenor – ger and colleagues, in Educational game design for online education [23], aimed to introduce guidance for integration of commercial games and online educational environment. For this purpose, a suitable game genre, which fulfills the pedagogical requirements, was chosen. Then assessments and adaption rules were integrated to the game model. Later, all of these were integrated to an online environment. The last step is known as implementation. Authors mentioned that developing an educational video game would be too costly. As a solution to it, they attempted to use a commercial video game and change it in a way that would cover their needs. Although this method would reduce development cost, it would require advanced technological skills. Using an educational game engine reduces both the expense of developing the entire game and the need for technological skills.

Mitgutsch and Alvarado [35] acknowledging the lack of analysis tools for serious games developed a serious game design assessment framework (SGDA). SGDA consists of a list of the six most important components of serious game design:
1) Purpose: Each game has a goal, which should be considered in the design step of development. It is essential to see if the serious game reaches its purpose or not.
2) Content: This component refers to the information and knowledge given by the serious game, which should be correct and applicable.
3) Fiction and narration: The story, characters, setting etc. set up the fictious and narrative characteristics of a serious game.
4) Mechanics: The rules of game world that agents use to interact with each other form the mechanics of the game.
5) Aesthetics and graphics: This component relates to the visual and audio components of the game. The information of the game most of the time is presented by game graphics.
6) Framing: Framing is about the audiences of the game, the target group's game play, usability and etc.

The relation of these elements affects the design of the game system. In his study the proposed principles were used to evaluate two developed serious game.

3.4. SERIOUS GAMES

In this section, some important studies, which were developed for teacher training, are described. After explaining each study in detail, the differences between the Projects and GATES are provided.

3.4.1. TeachLive

In 2007, University of Central Florida created a group of educators who developed a virtual classroom to train their students and apply the class management skills. TeachLive is a mixed-reality system, which simulates a classroom with five students that have different characteristics. This system not only helps the pre – service teachers to practice their management skill but also creates an opportunity for expert teachers to practice their new teaching ideas without risking students [10].

This system allows teachers to practice their skills in a virtual classroom. The system uses Microsoft Kinect. The trainee has to put on a headset to be able to communicate with the virtual students (avatars) [10]. An instructor or educator controls the avatars according to their personality and the situation.

Mathematics and science teachers as well as pre – service teachers use TeachLive system to practice their own teaching methods [10]. This system in not just used to handle students' misbehaviors, but also practice teaching skills on defined topics. The trainees perform one-hour teaching sessions for a semester. If a trainee experiences any problem about the teaching method, he or she can just simply replay the simulation without any side effects for the students, which is unlikely to be true in real life.

Currently, about 22 campuses in United States use the TeachLive system. This indicates that their market is only limited to the United States. This is a serious drawback for this system. Another limitation of TeachLive is the fact that it is not possible for two different trainees to use the lab at the same time because one individual controls the avatars. Another issue is the budget for the university to use the system [10]. The required amount of money may stop some of the universities to use this system despite their interest. In GATES, unlike in TeachLive, since the serious game is an online game and AI rules the students, multiple players could play the game simultaneously and receive feedback immediately.

Figure 3.2: A TeachLive session at Southern Louisiana University [10].

3.4.2. Second Life

Second Life (SL) is 3-D virtual interactive environment that was launched in 2003. Anyone can join this virtual world for free. This environment is an easy way to work on online applications. Members can easily make their own avatar, have a tour around the virtual world, and communicate with other avatars, (which are controlled by other persons all over the world). They could simulate what they would do in real life in the SL virtual world. The first purpose of developing SL was not educational, but SL started attracting educators as a tool for training. SL provides attributes of a good learning environment:

1. Simulating the situations you want
2. Easy to use
3. Communicating and socializing with avatars
4. Group work
5. Suitable for distance learning

These aspects make SL a good platform to be used as a serious game. Learning in SL is similar to that of a classroom with a group of students, which does instructor lead. Otherwise, it just could be like a conversation that everyone talks about his opinion about a specific subject. There are many studies, which use SL as a training tool. Many universities, colleges, or institutes in the real world get used to these aspects of SL, bought lands in SL and built a virtual university or a virtual institute to also provide a classroom or conference in SL. Harvard University is one of the famous universities that have a virtual campus in SL [36]. British Broadcasting Corporation (BBC) is another example of a company owning a land in SL. BBC has a foreign language institutes in SL to teach foreign languages such as English. But universities are not the only users of SL. Medical centers are another example. They simulate different difficult medical situations in their SL medical centers to train new physicians. Another interesting example is the National Oceanographic and Atmospheric Administration in the USA [36], which uses SL to simulate difficult situations such as tsunamis for educational purposes.

J.Mahon et al [37] used SL as a platform for classroom management practices. They purchased a private island in SL to avoid disruption of unwanted guests. On this island they built a school campus of four classrooms, a science laboratory, a lavatory and other

amenities. There were 30 middle school students in this simulation, which behaved according to their family background and educational level.

These students were controlled mainly by instructors and educators but also by AI software to supplement human controllers. The written AI software (a third party software – LibSL) was not excessively complex and was developed using a finite state machine with limited states such as sleep state, initial state and controlled states.

Figure 3.3: A Modeled Science Lab in Second Life [37].

SL was among the most successful projects in its area; however, it faced several problems. The most frequent one was due to the Internet connection performance since SL is an online software application. Another problem was related to the limitations of their AI software. It could control eight students (bots) at once; they had to run the same program on different machines to control more students [37]. Finally, the actual cost of the land was also an important issue. GATES also shares one main purpose with SL; however, in GATES there is not any limitation for the number of the students controlled by AI. There could be about 40 students in each classroom in GATES and there is no need for extra machines to control them all. Besides, teachers are trained to use and integrate technology to their classroom management methods, which results in hi – tech classrooms in GATES.

3.4.3. simSchool

SimSchool is an interactive 2-D classroom simulation that is used by teachers to practice their teaching skills. The player can create an account and immediately start controlling its simSchool's virtual classroom. According to Shaffer [38], this video game simulates a classroom fairly well and anyone with a limited teaching understanding can play the game. Through repetition, the player can become an expert. The game provides a list of options to choose from two groups of actions: asking students to do something or talking

with students. The game was developed using simSchool's engine. This game engine created students; assigned personalities for them and created actions' list and collected game play data. Populating the classroom is one of the game engine's tasks. The students inside the classroom have different personalities resulting from the combination of different attributes. To form the student's personality, one attribute value is selected from each and every of three attribute groups listed below [38].

1. Traits and Needs.
2. Learning Performances.
3. Social Expectations.

In addition to their personalities many other factors affect the way students behave. The conversation they are having with the teacher, and the way the teacher treats tem are some of the factors that affect their tendency to learn. SimSchool does not simulate a hi - tech classroom and this is considered as one of its major weaknesses.

Figure 3.4: A Classroom Created Using simSchool [38].

GATES, on the other hand, is a 3D teacher educating system that aims to train teachers to manage hi – tech classrooms and to master their TPACK skills.

In the next part, studies that surveyed ontology usability in serious games are mentioned. Afterwards, the relation between ontology and agent communication is explored. At last various works about ontology evaluation is explained.

3.5. ONTOLOGY

In their study, Schatz and Ruppel [39] suggested serious games as a suitable tool for practicing civil and building engineering. They pointed that for developing a serious game in this field, the needed knowledge could be gained using Building Information Modeling (BIM) process. However, in this process defining game components takes a long time if done manually. They proposed that developing an ontology based on the information available on BIM could be a solution to this problem. This ontology was developed using web ontology language (OWL).

In another study performed by Ghannem and Khemaja [40], a game ontology was provided to represent educational values of various video games. The authors showed that even video games that are developed for entertainment could be used as educational games. The ontology was developed based on game theory and IMS Learning Design (IMS -LD). It was formalized using OWL and Protégé, and was used as a reference to choose the best video game for education based on each learner's abilities.

Tang and Hanneghan [41] investigated a comprehensive video game model, which could be used in various stages of developing a serious game. They studied different available models like Game Ontology Project (GOP); however, they concluded that there was no model able to represent all aspects of designing a video game. Therefore, they developed an ontology that modeled all aspects of serious game, their attributes and relationships. The main serious games' contents they highlighted in their Game Content Model (GCM) were rules, play and aesthetics information of serious games. Figure 3.6 displays the GCM developed by Tang and Hanneghan.

Numerous studies about the usage of ontology in the field of video games have been performed in the researches mentioned above. In the followings, some works investigating ontology in agent modeling and communication will be reviewed.

Tu and colleagues [42] employed an ontological approach to model a student that could be used in Tutorial Agent System (TAS). TAS had the ability of recognizing student's errors according to chosen process to solve a problem. The teacher could not perform this method for each of the students in reality because it was too much time consuming. According to this information, TAS offered a personalized instruction to each student. In this study, an ontological approach was used to represent the InfoMap, the domain knowledge, which was composed of information about student's performance. According to Tu et al. using ontological method eased the process of preserving information in InfoMap.

In "Ontological Student Profile", Ameen et al. [43] proposed a detailed ontological student profile. The information modeled in this profile was categorized into three groups of personal information, academic information and general information. To simplify

reusing and sharing of the developed student profile, an ontological method was chosen. Figure 3.6 represents the student's general information part of ontology, which was developed in protégé 4.0.

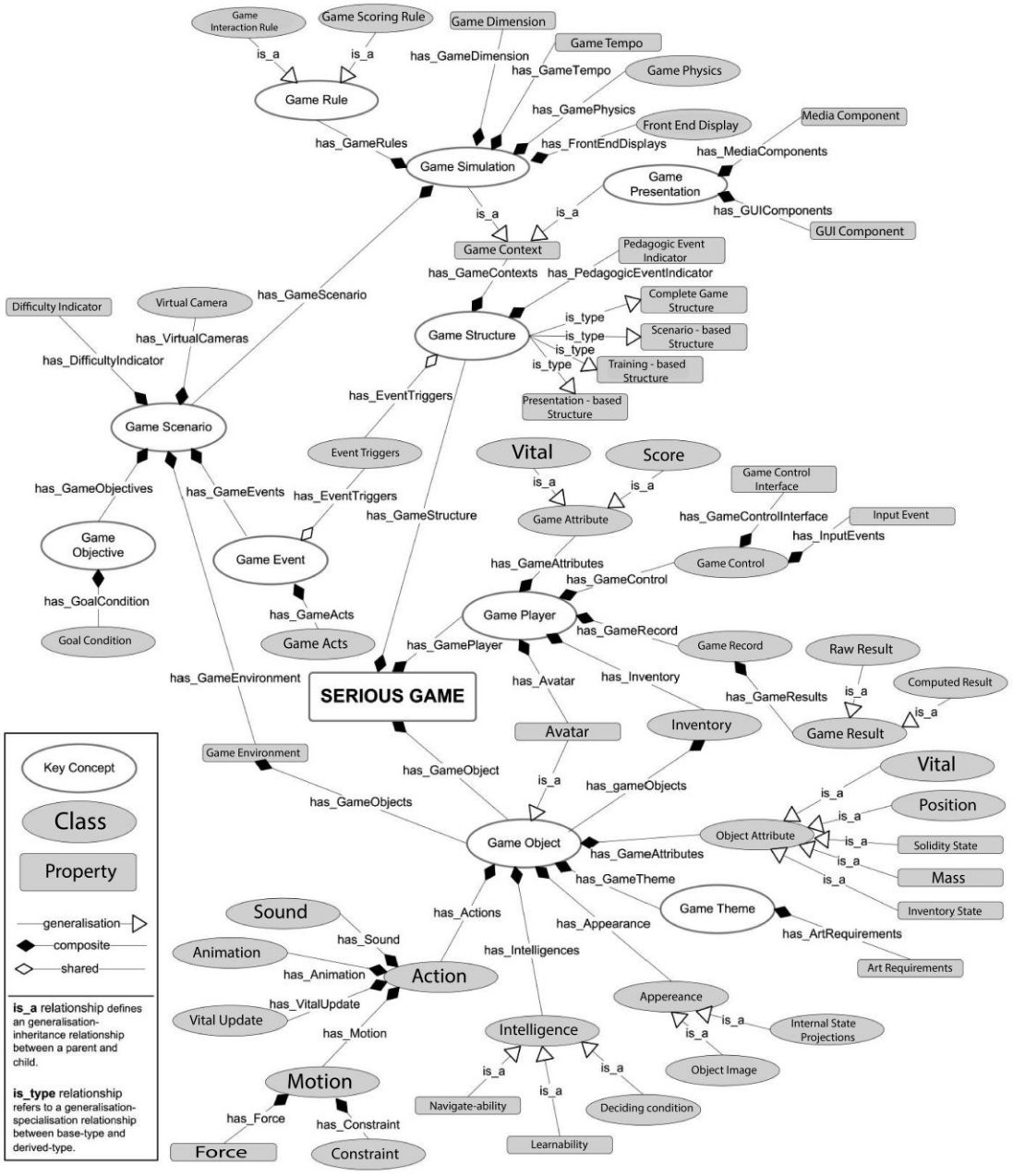

Figure 3.5: Game Content Model Developed by Tang & Hanneghan [41].

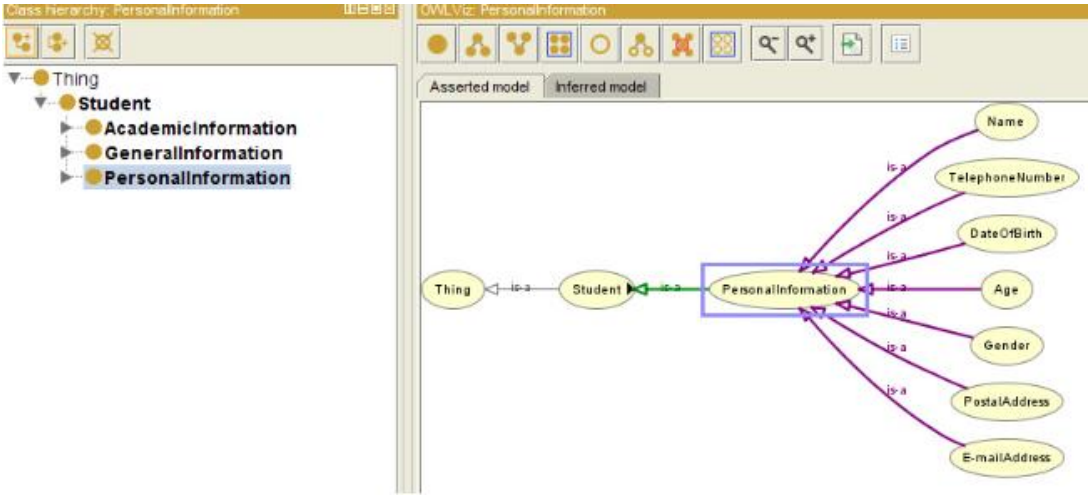

Figure 3.6: Ameen et al. Developed Student Profile İn Protege 4.0 [43].

Van Aart et al. [44] in their study discussed ontologies as a method for knowledge sharing and agent communication. For agent communication, they used the Foundational for Intelligent Physical Agents (FIPA) model that enabled agent communication via swapping messages. Using an ontology made it possible for agents to have a better understanding about facts of a domain. For developing their system they wrote a plugging for Protégé.

3.6. UML

Some works based on Unified Modeling Language (UML) for developing ontology are listed below.

Kogut et al. investigated the reasons to infer UML as an adequate tool for developing ontologies for agent – based systems. In their study they also refered to some works that had used UML as a tool for developing ontologies. additionally, they mentioned that UML could be a good choice for ontology modeling because of its standard mechanism for defining context specific extensions [45].

Wang and W. Chan investigated UML as a tool to assist in the process of mapping a knowledge model in a software model. They explained that developing an ontology using Protégé may not be intelligible for software engineers. Therefore, there should be a way to fill the gap between knowledge model and software model. UML is the most acceptable option to fill this gap. However, they stated that UML itself could not be sufficient and another language should be also used to declare the expressions related to models. They chose Object Constraints Language (OCL). UML class diagram and activity diagram was used to develop the ontology [46].

Bermejo-Alonso et al investigated the various usages of ontologies; in addition, the reasons why ontology could be used for agent – based systems and applications. They named UML as a tool to model ontology of agent – based systems [47].

CHAPTER 4

PROPOSED DESIGN APPROACH

To develop the corresponding ontology, the knowledge forming the ontology is explained in this chapter. The developed feedback system for GATES is discussed at the beginning of the chapter; then, TPACK and player evaluation follow. Afterward, the components of the proposed methodology are explained. At the end, the approach used to develop the ontology is provided.

4.1. GATES' FEEDBACK SYSTEM

One of the aspects of video games that, motivates a player to keep playing games, is the rewarding system. The rewards that the player receives while playing the game cause engagement with the video game and motivate the player to play more. There should be always a challenge or goal for the player to reach it. Needless to say, excessive rewarding does not have a good effect and can lead players to boredom. With this in mind and according to what mentioned in the previous section about classroom management, a rewarding system to acknowledge teacher's classroom-managing skill improvement was developed for GATES.

The topics evaluated by the GATES rewarding system are listed below:

- Classroom management skills.
- Using and integrating technical devices into their teaching methods.

In the GATES world, there are three components, which can affect the video games world with their actions: the teacher (player), a student and a group of students. All of these components have their own attributes. The attributes of student named Attention (Att), Disruptive Talk (DT), Involvement (Inv), Respect Teacher (RT), Understand Lesson (UL), Energy (En), and Temper (Tem). The attributes defined for a group of students are similar to the student attributes: attention, disruptive talk, involvement, and respect teacher, understand lesson, energy and Noise (N). The list of teacher's attributes is shorter and only contains: Control Over Class (COC) and Authoritarian Style (As). Any action of these groups could affect the attributes of all of them. According to the current values of these attributes, students choose their future actions. Affecting and updating these attributes according to player's actions is what GATES' rewarding system is responsible for. The method teacher chooses to teach a topic or deal with misbehaviors changes his or

her attributes. As a result of these changes students' behaviors are affected in a positive or a negative way. AI system of GATES also uses rules defined in GATES' feedback system to change pupils' behaviors.

For a better understanding, it is important to look the rewarding system's mechanism closer. Before developing the rewarding system, some of the best methods of teaching a topic or dealing with a specific misbehavior were chosen. The purpose of this serious game is to teach these methods to the players while playing and indirectly. This can be accomplished by sending feedback to the actions that players choose. Increasing or decreasing specific values of the teacher or students' attributes shows this feedback. Therefore, when the player applies the expected and defined actions, respectively in the system methods the rewarding system will increase the related attributes level. However, if the player uses a bad teaching method or a bad method to deal with a specific misbehavior, the rewarding system will decrease some of his or her attributes and by this way, his or her control over the class. Additionally, students' attention level will be lowered or classroom's noise will be increased. Therefore, attributes of teacher and students are constantly being updated and GATES's AI system uses these factors to decide the actions of each student in the classroom leading to a dynamically adjusted classroom. Therefore, in all of the scenarios of the game, there are some predefined misbehaviors that, will be triggered independently from player's choices and actions. These misbehaviors are chosen according to the flow of the actions defined in the scenario.

Based on the related work mentioned in the last chapter, some misbehavior and their proper dealing methods were chosen. These misbehaviors are categorized into four groups: minor misbehaviors, more serious misbehaviors, chronic misbehaviors, and hi – tech classroom misbehaviors. Since technology classrooms are almost new all over the world there wasn't a reliable reference to obtain the misbehaviors occurred in these classrooms. Hence, a list of hi – tech classroom misbehaviors was defined. Some misbehavior defined in the latter group of misbehaviors was obtained from interviews with the teachers in pilot schools of FATIH project.

A set of rules was defined in GATES' feedback system for each of misbehaviors. These rules are categorized into two groups based on: 1) the situation in which the misbehavior occurs, 2) on which factors and how they would be adjusted when the misbehavior occurs. There are also some other predefined rules depending on the actions of the player. These rules also categorized to two groups: 1) teaching methods 2) dealing methods. In each group the predefined rules show which factors are affected from the players chosen actions and how the chosen methods change these factors. For each of misbehaviors a list of accepted methods are defined according to literature references. The accepted methods to teach a mathematics topic also were defined by some members of the GATES project team. If the teacher chooses a method outside of the accepted methods the factors will be updated in a way that leads to a more troublesome classroom.

The Table 4.1 shows some examples of minor misbehaviors and their predefine rules. For a complete list of misbehaviors, see appendix A.

Table 4.1 Minor Misbehavıors And Their Related Rules.

Misbehavior	**Effects**	**The situation in which this misbehavior occurs**
Whisper	Att (-5), Dt (+5), N (+5), En (-5), Res (-5)	En > 30 & Dt > 60.
Talk	Att (-5), Dt (+5), N (+5), En (-5), Res (-5)	En > 30 & Dt > 60.
Laugh	Att (-5), Dt (+5), N (+5), En (-5), Res (-5)	En > 30 & Dt > 60.
Move in seat	Att (-3), As (-3), Ul (-3)	En > 40, Att<50, Ul < 40

In addition to the actions of the players, there is another factor that was taken into account while developing GATES' rewarding system. Since this video game is trying to train teachers to use technologic devices such as tablets and smart boards one of the skills, which are evaluated while playing, is the way players use and control these devices while teaching. At the beginning of the game, GATES have a tutorial part that introduces the devices used in the Hi – Tech classrooms of the "FATIH" project [8]. In the tutorial part, the features of technical devices are taught to the players. In addition, it is shown the proper way of using them while teaching. Then, when playing the game, the skills taught during the tutorial are evaluated. The teacher should be able to do the technical tasks proposed by the game in a proper amount of time while teaching. The way that the teacher uses the devices also triggers changes in his rewarding attributes as well as in students'.

The last factor that affects our rewarding system is time. For each lesson section, a specific duration not to exceed is defined. Different factors affect the teaching process. For instance, the methods used by the teachers and the misbehaviors happening in the classroom. In addition maximum acceptable durations are defined for each task given to the player during the teaching section. These tasks would be described in more detail in the next part. One example of these tasks is working with smart board or handling to control all students' tablets at once. Actually, for each task, two acceptable durations according to its difficulty level are defined. Minimum duration should be enough to perform the task in an ideal situation, which means that there wasn't any interruption. However, we decided to define a maximum duration of time if some misbehavior occurs and the teacher decided to deal with it right away before returning back to the task.

4.2. TPACK AND PLAYER EVALUATION

The methods, both for teaching a topic and dealing with misbehaviors, which are chosen by the players indicate their level of knowledge about classroom management. In each scenario of GATES, there are some tasks and challenges that the teacher should complete successfully. These tasks are the actions the teachers is expected to do while teaching in real life and they are categorized to TPACK to (Technological Knowledge) TK, (Pedagogical Knowledge) PK, (Content Knowledge) CK, (Pedagogical Content Knowledge) PCK, (Technological Pedagogical Knowledge) TPK, and (Technological Pedagogical Content Knowledge) TPACK. These tasks were defined by investigating the use of the technological devices available in the FATIH project classrooms, and, the problems that teachers mentioned in their interview. Although, GATES targets mathematics teachers, its focus is on mastering teachers' pedagogical and technological knowledge. It means that the tasks that classified in TK and PK groups' are more important than other groups. The list of task is given in appendix B.

For each scenario, to evaluate teachers, a list of given tasks is prepared and classified according to the TPACK classification. When the players encounter these tasks, the outcome of their choices (successfully completed or fail), will be saved and used to evaluate his skills. In addition, since the tasks are categorized, when a player fails to complete one of them it is possible to understand his or her weaknesses and to help him or her to improve. For instance, the player is directed to play specific types of scenarios in followed – up sessions. In the second level of GATES, scenarios are categorized according to the skills that they aim to evaluate. As pointed before, GATES focuses on PK and TK. Therefore, the second level scenarios only concentrate on TK, PK and TPK tasks.

After describing the feedback system and the teacher evaluation methods, in the next section the proposed methodology for designing serious games will be discussed in detail.

4.3. SERIOUS GAME DESIGN METHODOLOGY

According to Bloom [48], reduction in the number of students by different level of understanding from same issue is achievable by an effectual instruction. In other words, a good instruction can help learners with different abilities to reach similar educational outcomes. Like any teaching session, this approach can be used in serious games to teach players with different abilities and lead them to similar expertise level. In the field of education, different theories and models provide methodologies to reach a better instruction approach. Searching among these theories and models led us to Robert Gagné's nine event of instruction concept [6], which can be integrated into video games. Since these nine steps of Gagné fits properly with different elements and components of video games, this theory was chosen to be used in the proposed methodology. Gagné's events were then converted to serious theb components of the serıous game. Events new identity is described as followed:

Event 1: Gain attention: Gaining players' attention to play a game can be done by encouraging them. There can be different motivation and reasons for players to start playing game. Gaining information about a subject without paying attentıon to a tutor, learning while enjoying the learning process and practicing the newly learned skills without risk can lead players to start playing the serious game.

Event 2: Informing the learner about the objective: If learners are informed about the skills they will gain from the game, this will be motivated them to play. The main objectives of the game can be provided to the player using an introduction animation.

Event 3: Stimulating recall of prior learning: Prior knowledge sometimes refers to the skills that the player will gain from the tutorial part or from the earlier stages of game. It also includes player's knowledge from his or her former real world experience. Recalling of skills in most of the games is an iterative process. The players should complete each challenge by combining and linking previously known and newly acquired skills.

Event 4: Presenting the stimulus: At this step according to the learning task, the knowledge content should be provided to the learners. Well – organized video game scenarios would help the developers to provide the content to the learners.

Event 5: Providing learning guidance: In video games, guiding a player through a challenge can consist in giving hints. These hints can be provided in various forms such as a text or as a part of a dialogue between the player and Non – Player Characters (NPCs). In real classrooms, as mentioned before, the teacher decides about the level of guidance depending on the students' abilities, the duration of the lesson, etc. The same concept can be integrated into video games. The number of hints or their frequency depends on different factors such as the difficulty level of the game.

Event 6: Eliciting performance: After a player is provided with the new knowledge content, it is time to put player's newly acquired skills into practice. For this purpose, there should be specific challenges and puzzles during the game to give a chance to the player to practice newly gained skills.

Event 7: Providing feedback: The technique used in games to indicate the player about her/his decisions' and actions' outcome is a rewarding system. The feedbacks that provided by rewarding systems are varies. It can be a simple sentence, or numbers, which indicate the player's score, or energy bars that illustrates player's status.

Event 8: Assessing performance: The learner's performance at a certain game level, and the number of his or her correct and incorrect decisions is used by the serious game to evaluate his or her knowledge. Based on the player's performance during a game or a specific session, a feedback screen is provided. This screen displays the result of player's performance evaluation.

Event 9: Enhancing retention and transfer: At this level the student should be able to use her / his knowledge and skills to make proper decision in a situation same as reality. This situation can be a complex challenge that the player should complete by himself or herself thanks to his knowledge and skills.

A serious game developer should have objectives about these nine events from the beginning steps. These events are considered as a checklist to incorporate instructional theory into the serious game and they are the blocks that build the structure of serious

games. Gagné nine events constitute the theory that is required to develop our comprehensive methodology for designing serious games. By considering various video games from different genres, essential components of video games were obtained. Afterward, these elements were categorized according to their nature into the content and the game design group and these groups themselves are divided to some subsets. The Figure 4.1 indicates all of the components proposed in this approach. Classifying serious games' components into three groups of theory, content and game design was obtained from the heart of serious game design [5].

The subject that the serious game aims to teach, the target players of the game, the goal of the training, the available standards or rules, tutorial part of the game, skills and challenges are the elements of the content part. The topic(s) that are going to be taught must be detfined beforhand. The audiences and their needs and desires, affect the serious games. Hence, all these elements should be considered at the early steps of development.

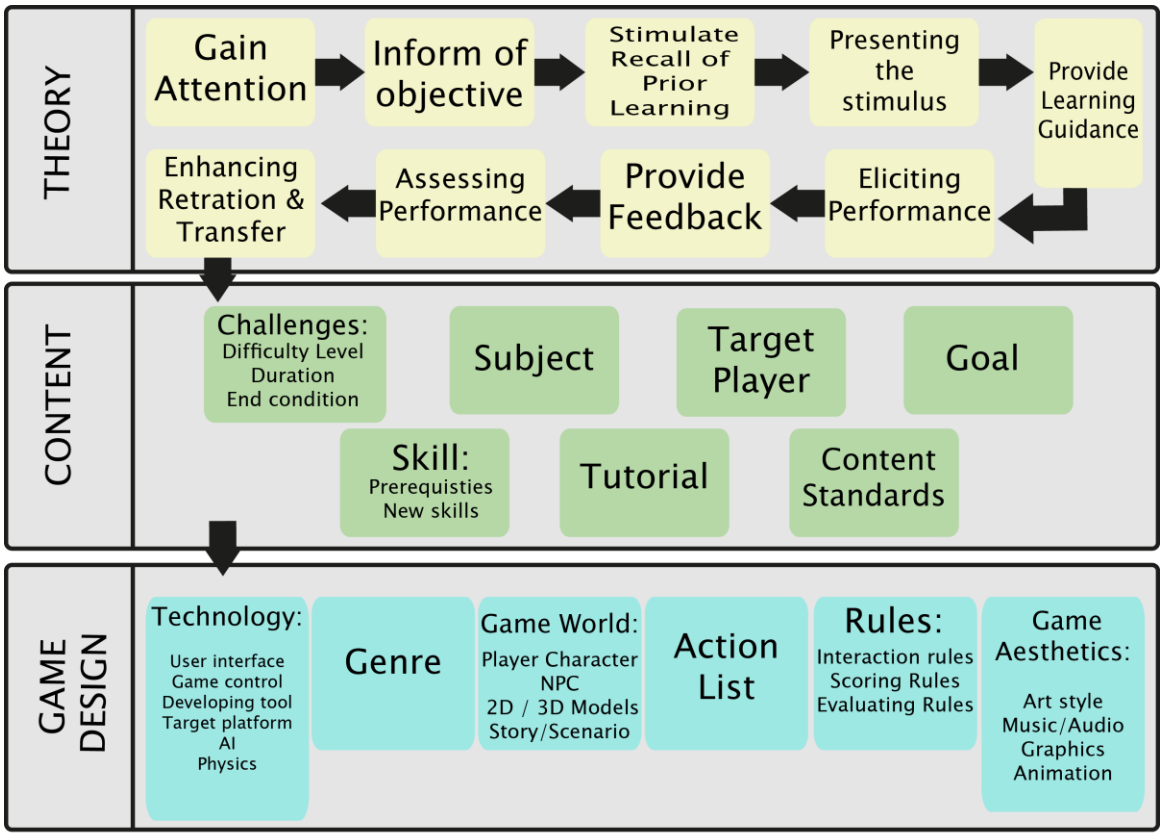

Figure 4.1: Components of Theory, Content And Game Design Parts Of Proposed Serious Game Design Ontology (SGDO).

The game design elements are components which are not only belong to serious games but also are available in most of video games. These components are forming the fun part of the games. One of the main characteristics of each game is its genre and many other elements are related to it. According to their genre,- most of the games have a game world that contain all the related actions. The player's character, NPCs and all other available models in the game should be prepared. The game's story and scenarios should be drafted

and the action list available to the characters or NPCs should be decided and developed. Another essential aspect of the game is the rules. The rules of interactions between the player and the other elements of the game, the rules of the rewarding system and of the players performance assessment should be decided. Game aesthetics relates with the elements which make the game appealing fort he player. Another important aspect in all of the video games is technical mechanics. The development tool or language should be chosen beforehand. The platform the game would be available to play, games level of interactivity should be decided and developed. The level of physics and AI used in game are very important factors. The interface used by the player to interact with the game should be designed very carefuly. It should be intutive and simple.

As it is obvious, the aim was to have a balanced focus on different aspects of a serious game. One part of these elements were taken into considaration while GATES' scenarios were designed. During the development process of the GATES' scenarios, some other elements were added and finally all of the proposed elements will form the ontology as described in the next part.

4.4. ONTOLOGY

As mentioned in previous chapters, ontologies are used for knowledge sharing in a specific domain. GATES like many other serious games contains many components, rules, object, and etc. To provide a better understanding of serious games components, ontology was designed. Then, this ontology was used to design GATES' ontology. The components of the developed ontology are the main objects of GATES' world and their properties, the actions that they can perform and the results of these actions.

To develop specific domain ontology, different methodologies can be followed. Noy and McGuinness proposed methodology is one of these methodologies [1]. This methodology was adopted to develop serious game design and GATES' ontology due to its simplicity and similarity to software designing. The steps, which are listed in the following, are the steps of Noy & McGuinness approach and are independent from the tool used to model the ontology [1].

1. Determine Domain and Scope
2. Consider Reusing Existing Ontology
3. Enumerate Important Terms
4. Define Taxonomy
5. Define Properties of Classes
6. Define Facets
7. Create Instance

At this point each step is explained in more detail.

1. Determine Domain and Scope

To determine the domain of the ontology there are some main questions that should be answered. These questions and answers are:

- **What is the domain that the ontology will cover?**
    - This ontology will be about developing a serious game for teacher education.
- **Why are we going to use the ontology?**
    - This ontology will indicate information about different serious game elements. It will also contain students' misbehaviors and class management methods in a Hi – Tech Classroom that will be used by AI agents in the video game.
- **For which question the information in the ontology should provide answer?**
    - How to develop a balanced serious game?
    - What are the main elements to consider in different serious games?
    - What are the better methods for teaching in a Hi – tech classroom?
    - How should the teacher control and use technological devices in education?
    - What are the best methods to deal with students' misbehaviors?
    - Whether the methods chosen by the teacher (player) could increase or decrease student's misbehaviors?
    - How different character types of students misbehave and how the teacher could deal with them?
- **Who will use and maintain the ontology?**
    - Anyone interested in developing a serious game can use this ontology to have an understanding about the parts a serious game should have.
    - This ontology will represent GATES' rules and mechanics; hence, it will be used by whoever is involved with the game development process and the AI agents' development process.

2. Consider Reusing Exiting Ontology

While an ontology is developed, other systems and researchers can use it, further, using an available ontology instead of developing it from the scratch is suggested. Unfortunately there wasn't any ontology related to a serious game about classroom management, which covers our needs and answers the questions we need for developing our system. Therefore, we decided to create an ontology, which covers all aspects of our project, nevertheless, we cannot pass without mentioning some researches related to our field of interest. De Kereki and his colleagues [49] modeled a learning environment using

ontology to define and manage different kinds of knowledge. Sani and Aris [50] used fuzzy logic and an ontology to form a student model able to represent his or her learning progress. Paneva [51] used ontology for modeling students to use in a multimedia digital library for an e-Learning process.

3. Enumerate Important Terms

In this step a list from all-important terms, which the user should know, was prepared. In addition, their properties were listed. Creating the list of classes (nouns) and their properties (verbs) was performed in this step [1]. Some instance of this list were: teacher, student, behavior, chosen lesson topic.

4. Define Taxonomy

For making the hierarchy of the class, there are three different methods: Top – down method, bottom – up method and a combination of both. For this project top – down method was applied.

5. Define Properties of Classes

In this step, properties (slot) of each class will be defined. According to Yuhana, properties are the relation between two individual. He devieded these relations into three groups [52]:

- Object Properties
- Data Type Properties
- Annotation Properties (Extra information about classes, individuals and object/ data type properties)

Otherwise, this is not the only method to define object properties. Noy and McGuinness's categorization of object properties is as listed below [1].

- Intrinsic Properties
- Extrinsic Properties
- Parts (if the object is structured)
    - Physical
    - Abstract
- Relationships to other individuals (Relationship between member of the class and other items)

6. Define Facets

For each slot, information such as value type, allowed value, number of values (cardinality) should be specified [1].

According to [1] different types of values are considerable, which are listed below:

- String (A simple String)
- Number (Integer, Float)
- Boolean
- Enumerated (Specify a list of allowed values for the slot.)
- Instance-type (Definition of relationship between individuals)

Slot Cardinality defines how many values a slot can have. In some systems, cardinality could be single cardinality (a single value) or multiple values (any number of values). Some other systems have a minimum and maximum value for indicating number of slot values [1].

These steps were followed to design the ontology. After that it was time to choose a proper tool for developing the ontology.

4.5. UML

A significant step at ontology development process is to decide on a suitable tool to model the ontology. For designing the ontology at first Protégé 3.4.8 and Protégé 5 tools were chosen. Then Unified Modeling Language (UML), which is a more compatible tool with software ontologies development, was used instead of Protégé. ArgoUML [53] a free open source UML tool was used for this purpose. Among UML diagrams, class diagram, was utilized to develop the ontology. Figure 4.2 and Figure 4.3 illustrate two ontologies developed in the scope of this thesis, Serious Game Design Ontology (SGDO) and GATES' ontology. More detail about components of these ontologies is available in Appendix C.

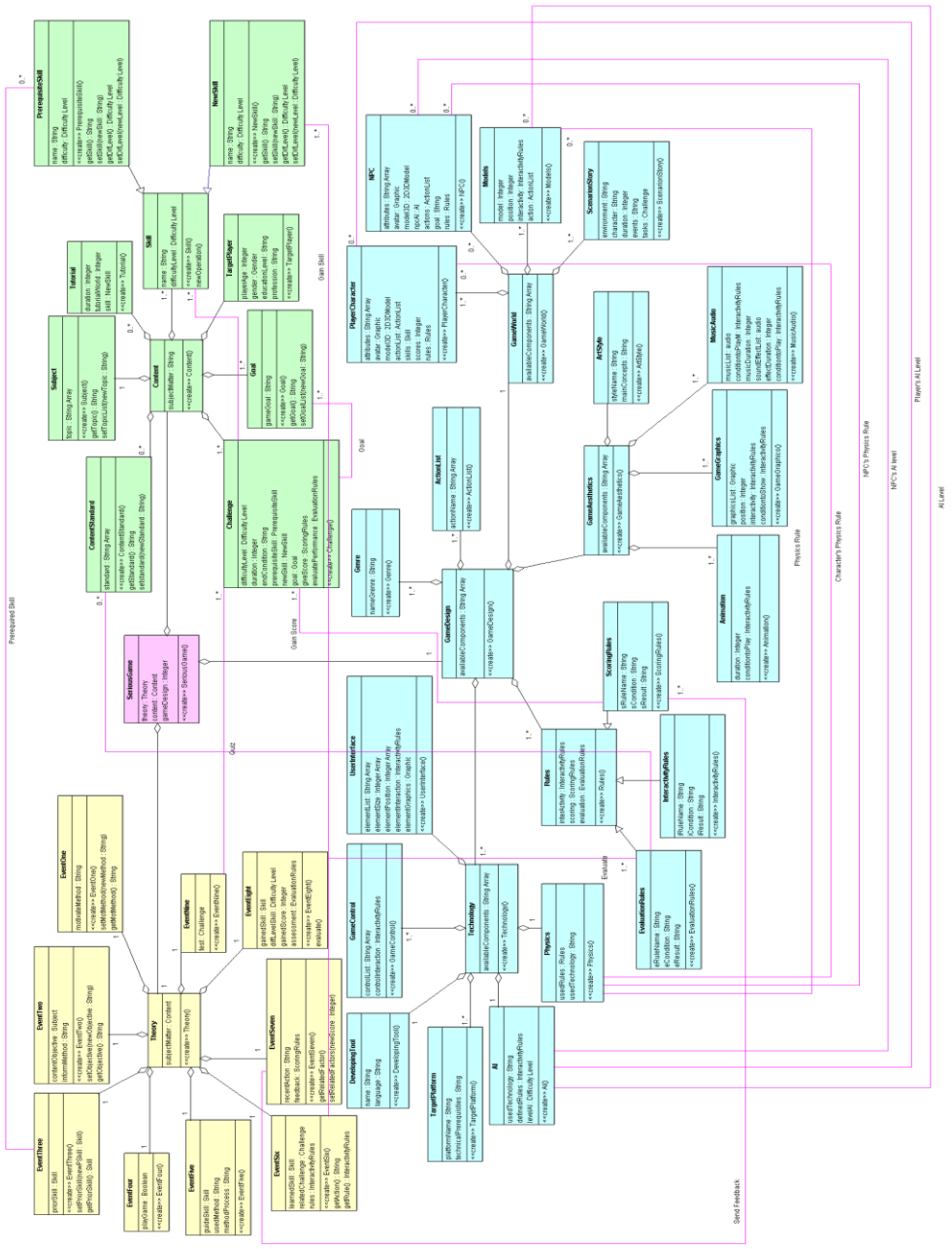

Figure 4.2 Proposed Serious Game Design Ontology (SGDO).

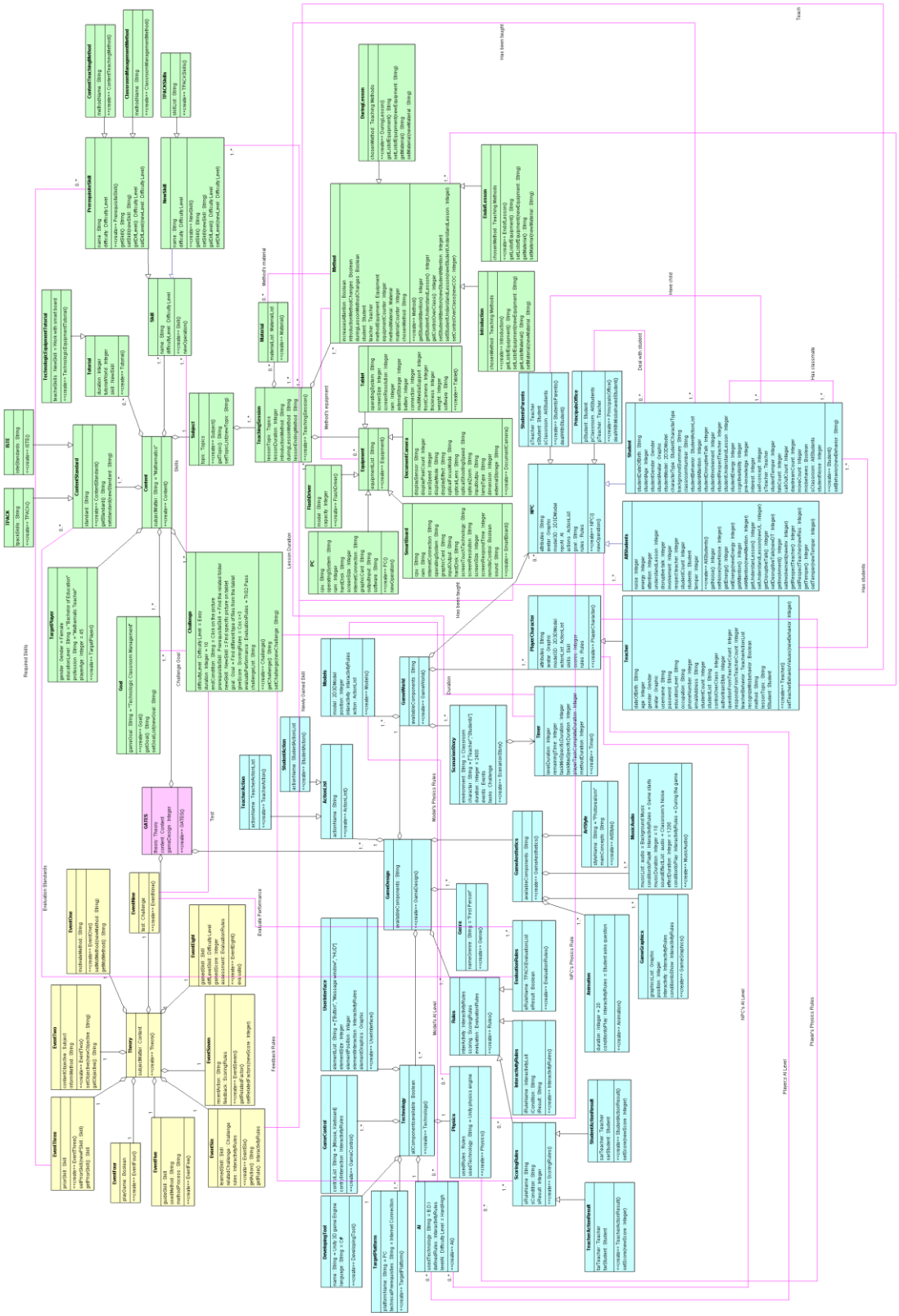

Figure 4.3 Proposed GATES' Ontology.

In this chapter, the aim was to explain the approach proposed in this thesis step by step. Besides, the process of developing the ontology was described in detail. Later, an explanation about each component of GATES' ontology was given. Fallowing chapter provides a discussion about the serious game design methodologies that this thesis presents.

CHAPTER 5

DISCUSSION AND CONCLUSION

This chapter provides a discussion about the methodology proposed in the scope of this thesis. A conclusion would be followed.

5.1. DISCUSSION

By expansion of serious game market, many video game developers and educators attempt to develop a serious game to become a member of this society. Still, not all of them succeeded. Plenty of developed serious games could not reach the goal, which they persuade. Those games were either a good tutor without any fun factors or an entertaining game without any educational outcomes. To design and develop a serious game a team of game developers and education experts are needed. In the process of developing a serious game, the methodology, which has been chosen by development team, is very significant. As a consequence, the lack of a remarkable methodology for developing a serious game is felt. To cover this deficiency, this thesis proposed a serious game development methodology that covers different components of a serious game. During developing this methodology it was attempted to concentrate on both educational and entertainment aspects of serious games. This approach provided a balance between serious and fun parts of a serious game that result in an appealing learning experience.

Diverse methodologies are available in literature to develop a serious game. One of these studies is proposed by [5]. This methodology was inspired by MDA framework, and resulted in another framework called DPE framework. In DPE for development of serious games learning, storytelling, gameplay and user experience levels are suggested. By the way, the author hasn't name the components building of these levels yet, there are some suggestions for different part. Needless to say, it is the developer's task to find a suitable instructional theory or any other component for each level. Comparing DPE with the methodology proposed in this thesis, it is clear that all of these aspects are named in the methodology that has developed for this thesis. Furthermore, in our methodology, a suitable instructional theory is chosen and integrated to the methodology.

In [35], the suggested framework is used for serious game assessments. The factors this framework focuses on are most related to game design part of the serious game, and education part of the game is not evaluated in detail. This framework analyzes content of a serious game, and the information the serious game provides, not the way it presents this information to reach an effective teaching. The features that have discussed in [35] are just small category of all the aspects that the methodology of this thesis has focused on.

In contrast to the researches mentioned above, in [22] the author focuses on various learning theories to integrate them into serious games, in hope of a better training. Gagne's nine events of instruction, Blooms taxonomy and Keller's ARCS model were studied in this research. Later, these theories were merged to be suitable and useable for serious games. Nevertheless, other factors about the subject the game would teach, different aspect of the game design is not mentioned in this study. The study, which the authors did in learning theories, is remarkable; however, their approach has some shortage in game design part.

The methodology provided by this thesis attempt for covering the aspects, which make a serious game both instructional and enjoyable. For this purpose one of the most remarkable theories in instructional field was chosen and combined with factors that make a video game full of fun and really entertaining. The result was an ontology, which modeled essential components of serious games, which the developer should take into consideration while developing a serious game.

In Table 5.1 results of the evaluation of our proposed Serious Game Design (SGD) approach and other methodologies are proved. The aim was to illustrate each methodology's advantages and weaknesses. Table 5.1 represents the aim of the above-mentioned methodologies of designing serious games. It represents that whether these methodologies are for designing serious games or their main purpose is to evaluate and upgrade the serious game. Educational and Game Design aspect columns of Table 5.1 argue if the methodology set sights on the both essential elements of each serious game: educational aspect and game design elements or not. The last column indicates the provided structure of the methodology. Choosing the right structure for the methodology can improve its effectiveness. As discussed before ontologies have many valuable features and using ontology to develop our proposed methodology enhance our approaches usefulness.

Table 5.1 Evaluation Results of Our Proposed Serious Game Design (SGD) and Available Approaches

APPROACH	EVALUATION/DESIGN	EDUCATIONAL ASPECT	GAME DESIGN ASPECT	STRUCTURE
SGD	Design	Available	Available	Ontology
SGDA	Evaluation	Unavailable	Available	Framework
RETAIN	Design	Availble	Unavailble	Model
DPE	Evaluation	Unavailble	Availabe	Framework

Table 5.2 evaluations between our proposed ontologies and available ontologies in the field of developing serious game design or education. Aim of developing each ontology is provided. According to the aim of each ontology, the concepts that these ontologies try to focus and cover is provided. In "level of focus" column, according to the knowledge domain scale, defined concepts in each ontology was assessed. The language used to develop an ontology is also essential while assessing to reuse it.

Table 5.2 Evaluation of Our Proposed Ontologies and Available Ontologies

ONTOLOGIES	PURPOSE	FOCUS	LEVEL of FOCUS	LANGUAGE
SGDO	Serious Game Design	SG Elements, Educational Theory	High	UML
GATES	Teacher Education Serious Game	SG Elements, Educational Theory, Teacher Education	High	UML
GCM	Serious Game Design	SG Elements	Medium	UML
ONTOLIGICAL STUDENT PROFİLE	Student Profile used in Educational Environments	Student Profile	High	PROTÉGÉ

5.2. CONCLUSION

This study aimed to develop an ontology – based serious game development approach. For a better training, various theories in field of education were studied. Gagne's nine event of instruction [6] which promise a more affective learning session was chosen to form the theory part of the provided methodology. Afterwards, the most required components of serious games were selected and categorized into game design and content groups. Later all of these components were used to form the ontology.

The proposed ontology could be used to develop serious games of various genres. In scope of this thesis, the developed ontology was used in development process of a teacher education serious game, called GATES. For this purpose, classroom management domain and TPACK components were added to the ontology. Besides, a rewarding system for GATES was developed and added to ontology.

The developed ontology could be used as checklist and guide for developers in the starting levels of serious game. All kinds of serious games could utilize this methodology for development. Care must be taken that some of the proposed components may not be necessary for different genres and can be omitted.

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APPENDIX A

REWARDING SYSTEM

In this part, rules defined for GATES rewarding system is represented. Student misbehaviors' are categorized into four groups (minor, more serious, chronic, high-tech classroom). For each misbehavior there are two sets of information; one shows that how student's and teacher's factors are affected by the misbehavior; the other set represents the value of factor when the misbehavior occurs.

Table A.1 List of Minor Misbehaviors

Misbehavior	**Effects**	**The situation in which this misbehavior occurs**
Whisper	Att (-5), Dt (+5), N (+5), En (-5), Res (-5)	En > 30 & Dt > 60.
Talk	Att (-5), Dt (+5), N(+5), En (-5), Res (-5)	En > 30 & Dt > 60.
Laugh	Att (-5 Dt (+5), N (+5), En (-5), Res (-5)	En > 30 & Dt > 60.
Move in seat	Att (-3), As (-3), Ul (-3)	En > 40, Att<50, Ul < 40
Call Out	As (-3), Inv (+2), N (+5)	Att>50, Ul > 50, En > 30, Inv > 60
Daydream	Att (-10), Ul (-10), Dt (-3)	Ul < 30, As < 50, Att <35, En < 40
Sleep	Att (-10), Ul (-10), Res (-5), As (-10), Dt (-3)	En < 25, Res < 30, Att < 30, Ul < 20, Tem < 30, As < 25
Play with tools (pens, ruler, book)	Att (-5), Ul (-5), N (+2), As (-3)	Att < 40, Ul < 30, Tem < 50
Draw on book	Att (-3), Ul (-3)	Att < 35, En < 40, Ul < 30
Pass notes	Att(-3), Ul (-3), As (-3)	Att < 35, Dt > 60
Walk around the classroom	Att (-5), Ul (-5), En (-3), N (+5), As (-5)	Att < 20, Tem > 70, En > 30, As <30, Res < 30
Come without supplies	Att (-3)	Att < 20, As < 30, Res < 30
Go out	Ul (-5), N (+2), As (-1)	Att < 30, Ul < 40

Table A.2 List Of More Serious Misbehaviors

Misbehavior	**Effects**	**The situation in which this misbehavior occurs**
Disobey teacher (Continual Defiance)	As (-3), Tem (+3), Res (-5)	Res < 30, Att < 30, As < 30, Coc < 40
Hurt	Att (-3), Tem (+5), N (+5), En (-3), As (-5), Res (-5)	Tem > 70, En > 60, Att < 30, As < 30
Punch	Att (-3), Tem (+5), N (+5), En (-3), As (-5), Res (-5)	Tem > 70, En > 60, Att < 30, As < 30
Poke	Att (-3), Tem (+5), N (+5), En (-3), As (-5), Res (-5)	Tem > 70, En > 60, Att < 30, As < 30
Fight	Att (-3), Tem (+5), N (+5), En (-3), As (-5), Res (-5)	Tem > 70, En > 60, Att < 30, As < 30
Damage material	Tem (+2), N (+2), As (-3), Coc (-3), Res (-2)	As <40, Res < 30, En < 40, Att < 20
Arriving late	Att (-3), Ul (-3), N (+1), As (-1), Res (-2)	Att < 20, Res < 30, As <30, time > 10
Answer cell phone	Res (-5), Att (-5), Ul (-5), N (+3), Dt (+2), As (-5)	Res < 30, Att < 30, Tem > 40, As < 30, N > 30
Yell	Att (-10), Ul (-10), Tem (+10), N (+10), Res (-10), As (-10)	Res < 10, Tem > 40
Bully	Att (-10), Ul (-10), Tem (+10), N (+10), Res (-10), As (-10)	Res < 10, Tem > 40
Physical Threaten	Att (-10), Ul (-10), Tem (+10), N (+10), Res (-10), As (-10)	Res < 10, Tem > 40

Table A.3 List Of Chronic Misbehaviors

Misbehavior	Effects	The situation in which this misbehavior occurs
Argue	Res (-5), Tem (+4), N (+4), Dt (+3), As (-5), Coc (-3)	Res < 20, As < 20, Tem > 60, Dt >30
Taunt	Res (-3), Tem (+1), N (+2), As (-2)	Res < 20, As < 30, Dt > 50
Insult	Res (-3), Tem (+1), N (+2), As (-2)	Res < 20, As < 30, Dt > 50
Comment Frequently	Tem (+1), As (-3), N (+3), Coc (-2)	Inv > 60, Res <50, Att > 65, Ul > 70
Move on seat frequently	Att (-3), Ul (-2), N (+1), As (-3)	Att < 35, En > 50, As <40
Be out of desk	Att (-3), Ul (-3), Tem (+1), N (+2), As (-2), Coc (-2)	Att < 25, Ul < 20, Res < 30, En > 70, As < 30, Tem > 60, Dt > 65
Daydream Frequently	Att (-5), Ul (-5), Dt (-5)	Ul < 30, As < 50, Att <35, En < 40
Injure self	Tem (+5), N (+5), As (-10), Res (-5), Coc (-5)	Res < 10, Tem > 70, En > 60, As < 20
Continuously speak with neighbors	Att (-5), Ul (-5), N (+3), Dt (+3), As (-5)	Att < 40, Ul < 50, Dt > 50, N > 20
Call out Frequently	N (+3), As (-5)	Att > 65, Ul > 75, En > 30

Table A.4 List Of Hi – Tech Classrooms' Misbehaviors

Misbehavior	Effects	The situation in which this misbehavior occurs
Play Games	Att (-5), Ul (-5), N (+1), As (-3), Res (-3)	Att < 20, Ul < 20, As < 30, Res < 30
Idle Surf on the internet	Att (-3), Ul (-3), Res (-2), As (-3)	Att < 30, As < 30, Res < 40, Ul < 30
Personal Work	Att (-3), Ul (-3), Res (-2), As (-3)	Att < 30, As < 30, Res < 40, Ul < 30
Send instant Message	Att (-5), Ul (-5), Res (-5), As (-5), Dt (+2)	Att < 30, Ul < 40, Res < 30, As < 40, Dt > 50
Write text message	Att (-5), Ul (-5), Res (-5), As (-5), Dt (+2)	Att < 30, Ul < 40, Res < 30, As < 40, Dt > 50
Damage equipment	Tem (+2), N (+2), Dt (+2), As (-3), Coc (-3)	As <40, Res < 30, En < 40, Att < 20
Come without tablet	Att (-3)	Att < 30, As < 30, Res < 30
Hack teacher laptop	Res (-5), Coc (-10), As (-10), Att (-5), Tem (+10), N (+10)	As < 30, Res < 20, Att < 30
Film	Res (-7), N (+3), Tem (+3), As (-3)	As < 30, Att < 30, Res < 20
Take Photograph	Res (-7), N (+3), Tem (+3), As (-3)	As < 30, Att < 30, Res < 20
Tape	Res (-7), N (+3), Tem (+3), Att (-3), As (-3)	As < 30, Att < 30, Res < 20

Fallowing defining the misbehaviors, the teacher's actions and deal methods are defined in rewarding system.

Dealing with Minor misbehaviors

Table A.5 List Of Nonverbal Intervention

Player's Actions	Specific Student
Look at student	Att (+3), As (+3), Res (+3)
Use hand signals	Att (+3), As (+3)
Move closer to student	Att (+5), As (+5), Dt (-5)

Table A.6 List Of Verbal Interventions

Player's Actions	Specific Student
Say student's name	Att (+3), Dt (-2), As (+3), Res (+2)
Incorporate name into instruction	Att (+3), Dt (-3), As (+3), Res (+3)
Call on for participation	Att (+3), Dt (-3), As (+3), Res (+3)
Use humor	Res (+3), Att (+3), As (+3), Dt (-3)
Direct student to the task	Att (+3), As (+3), Res (+3)
Remind rule	Att (+3), Res (+3), As (+3)

Dealing with More Serious Misbehaviors

Table A.7 List Of Approved Penalty

Player's Actions	Specific Student
Take away Privileges	As (+3), Att (+3)
Time – Out	As (+4), Att (+4), Dt (-3)
Assign to write reflection	As (+3), Att (+3)
Assign to Visit the Principal's Office	As (+5), Att (+4)
Penalize with detention	As (+3), Dt (-3), Att (+3)
Contact with the Parents	As (+4), Att (+3)

Dealing with Misbehaviors in Hi-Tech Classrooms

Some of the misbehaviors categorized under this group are similar to some misbehavior, which discussed in other groups. The only difference is that they occur by using a technical devise; so, dealing with them would be alike, just name categories are named close to misbehavior, as player could choose a dealing method according them.

- Instant messaging could categorize in "More Serious" group.
- Damaging Equipment categorized in "More Serious" group.
- Forget to bring laptops/ tablets to class could be in "Minor Misbehaviors".
- Filming/ Photographing or sound recording with their laptops/ Tablets could be in "More Serious" group.
- Playing Games could be "Minor Misbehavior".
- Idle Surfing on internet/ his files in his tablet/ doing his own works could be "Minor Misbehavior".

In case of hacking computers and laptops, which is one of the newest misbehaviors that is probable to take place in classroom, since there is no suggested method, teachers can follow the method in the Table A.8.

Table A.8 Dealing With Hacking Teacher's Laptop

Player's Actions	Specific Student
Make troubleshooter	As (+5), Res (+5), Coc (+5)

A group of wrong dealing methods are listed in the Table10, which are not acceptable for any misbehavior groups; however these methods some times are used by teachers, there for, we use them to mislead teachers when trying to choose the right dealing method.

Table A.9 List Of Wrong Dealing Methods

Player's Actions	Specific Student
Knock on table	Att (-5), As (-5), Res (-3)
Yell	Att (-5), As (-5), Res (-3)
Shake	Att (-10), Res (-10), As (-10)
Touch	Att (-10), Res (-10), As (-10)
Ridicule	Att (-5), As (-8), Res (-6)
Send out of class	Att (-5), As (-10), Res (-5)

Non – Misbehavior Action

There are also some actions (for both teachers and students) that belong to no misbehaviors and their dealing methods groups. Hence these actions are some part of real world classrooms; they are modeled in GATES.

Table A.10 Teacher's Other Action

Circulate around the classroom	Coc (+4), Att (+2), N (-2), As (+3)
View students' profile	Coc (+2), As (+2)
Technologic equipment usage	Coc (+3)
Being idle (Does nothing – Not teaching, Not doing tasks, Not dealing with misbehaviors)	Att (-3), Dt(+2), En (-2), Inv (-2), Res (-2), As (-3), Coc(-3)

Table A.11 Students Other Actions

Listen	Ul (+3)
Do activity	Ul (+5)
Take note	Ul (+4)
Read	Ul (+3)
Ask Question	Ul (+5)
Answer Question	Ul (+2)

Conditions below indicates the situation when the actions listed in the Table A.11 presented.

Listen:

Teacher is teaching
Att>30
Res>40
En>20

Does Activity

Teacher gives activity papers
Att>40
UL>40
Res>40
En>20

Take Note:

Teacher is teaching, reads the book (e-book)
Att>60
UL>60
En>20

Read:

Teacher is teaching from book - e-book or asks the student to read the book.
Att>40
UL>20

In addition to the methods that a teacher uses to deal with misbehavior, the method that the teacher chooses to teach is also will be scored. The marks that teacher might scored while choosing each of the teaching methods is indicated in Table A.12.

Table A.12 Used Lesson Methods in Gates

Introduction	Use introduction Method	History	Att (+3)	If Att> 30, Res>40, En>20 student **Listens.** If Att>60, Ul>60, En>20 student **Takes Notes.**
		Connection to daily life	Att (+3)	
	Doesn't use introduction method	Attention graving inquiry	Att (+3)	
During Lesson	Inquiry teaching	Group Work with Concrete Material	Att (+3), Ul (+3)	If Att>40, Ul>40, Res>40, En>20 student **Does Activity.**
			Coc (+3)	
		Group Work with Abstract Material	Att (+4), Ul (+4)	
			Coc (+3)	
	Direct teaching	Use tablet and e-book	Att (+1), Ul (+1)	If Att> 30, Res>40, En>20 student **Listens.** If Att>60, Ul>60, En>20 student **Takes Notes.** If Att>40, Ul>20 student **Reads.**
		Use a book	----	
End of Lesson	Take quiz Give homework	---	Coc (+3)	

APPENDIX B

GATES' PLAYER TASKS

The tasks given to the players while s/he is playing GATES are listed below. These tasks were categorized by taking ISTE standards and different TPACK studies which mentioned earlier into consideration. Player's weakness in each of these groups will lead her/him to different scenarios in second level of the GATES. However, in GATES the focus is on pedagogy and technology knowledge of teachers. Therefore, tasks belong to TK and PK group are more than other groups.

TK (Technological Knowledge):

- **TK01:** Find related abstract materials like pictures to topic before the classroom from some source like Internet (using her/his PC, tablet or smart board).
- **TK02:** Find different type of files from her tablet.
- **TK03:** Send different type of file to smart board.
- **TK04:** Find the topic in e-book.
- **TK05:** Send the e-book to student's tablets.
- **TK06:** Draw a table or a figure on smart board.
- **TK07:** Fill the table on tablet / Smart Board.
- **TK08:** Send the activity/ activity link to students' tablet.
- **TK09:** Find documents on the smart board.
- **TK10:** Open different type of files on smart board.
- **TK11:** Could zoom in or out in different files like activity papers.
- **TK12:** Could work with GeoGebra.
- **TK13:** Could send GeoGebra activity to students' tablet.
- **TK14:** Could open a GeoGebra activity on smart board.
- **TK15:** Show all students' activity answers on smart board.
- **TK16:** Use external devices probably. (Hard disks, Flash memories, etc.)

PK (Pedagogical Knowledge):

- **PK01:** Prepare a lesson plan for the topic.
- **PK02:** Prepare all the equipment and materials related to the chosen method and topic.
- **PK03:** Relate the topic to a daily life.
- **PK04:** Recognize misbehavior.
- **PK05:** Deal with the misbehavior.
- **PK06:** Describe short history about the topic.
- **PK07:** Chooses the right group work and be prepare for that by choosing the right materials for it.
- **PK08:** Hold discussion session after each group works.
- **PK09:** Find an intriguing question.
- **PK10:** Check the student groups while doing group works.
- **PK11:** Circulate around the classroom to check everyone is doing well.
- **PK12:** Shows students how to do the activity.
- **PK13:** Takes quiz (paper base).
- **PK14:** Asks students to participate.
- **PK15:** Control the students profile before the classroom.
- **PK16:** Pay attention to students' parameters.

CK (Content Knowledge):

- **CK01:** Recognize the wrong answers of students.
- **CK02:** Solve the question displayed on smart board.

PCK (Pedagogical Content Knowledge):

- **PCK01:** Correct the wrong answers of students.

TPK (Technological Pedagogical Knowledge):

- **TPK01:** Control the tablet of the students from her tablet.

- **TPK02:** Ask students to solve some problems on smart board.
- **TPK03:** Takes Quiz (uses tablet and smart board).
- **TPK04:** Deal with students' problems with their tablets (for example giving charger to them).

TPACK (Technological Pedagogical Content Knowledge):

- **TPACK01:** Able to teach about how to work with GeoGebra.

APPENDIX C

SERIOUS GAME DESIGN ONTOLOGY AND GATES ONTOLOGY

In this chapter, components of developed ontologies, Serious Game Design Ontology (SGDO) and GATES' ontology will be explained.

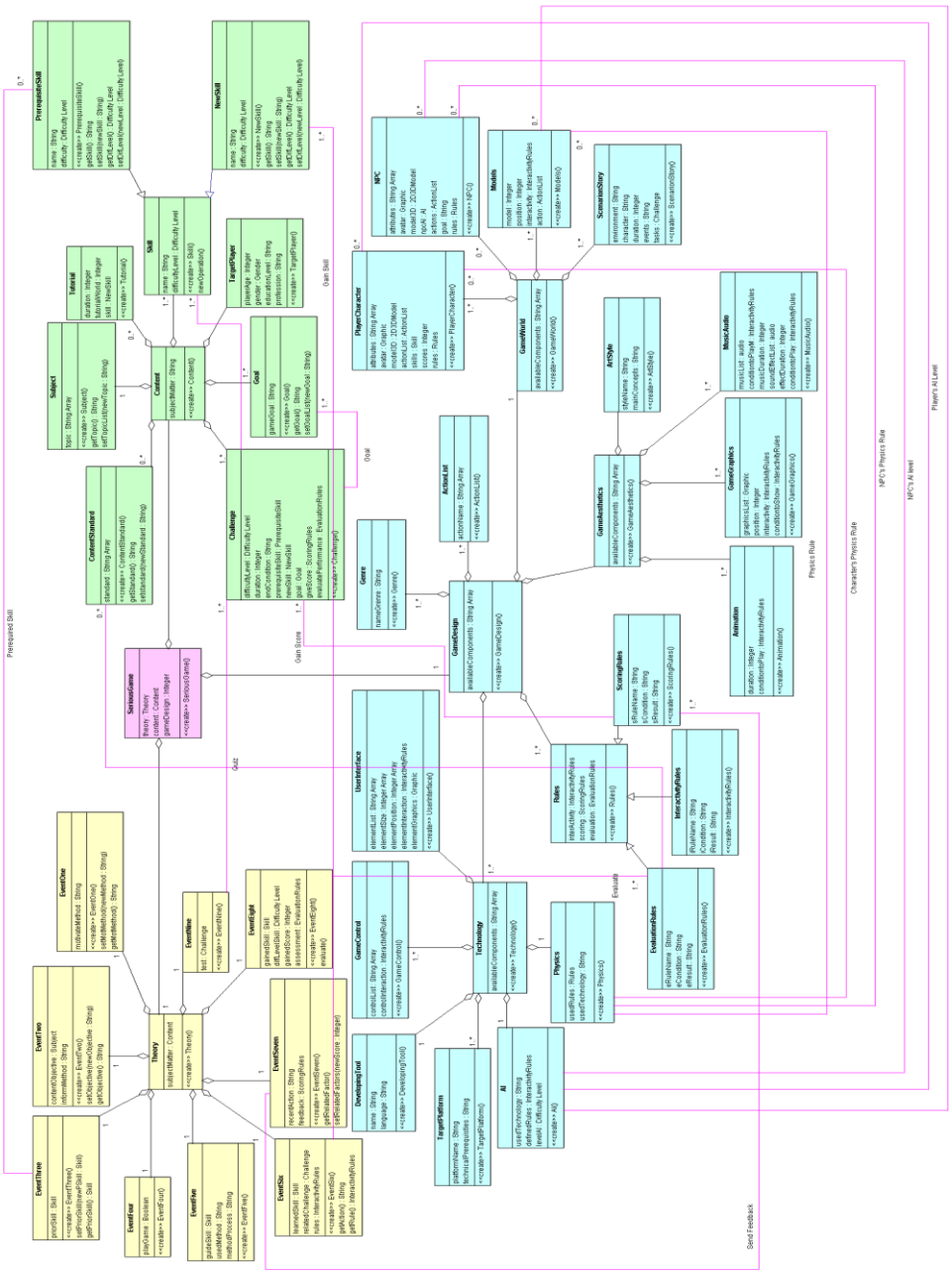

Figure C.1 Proposed Serious Game Design Ontology.

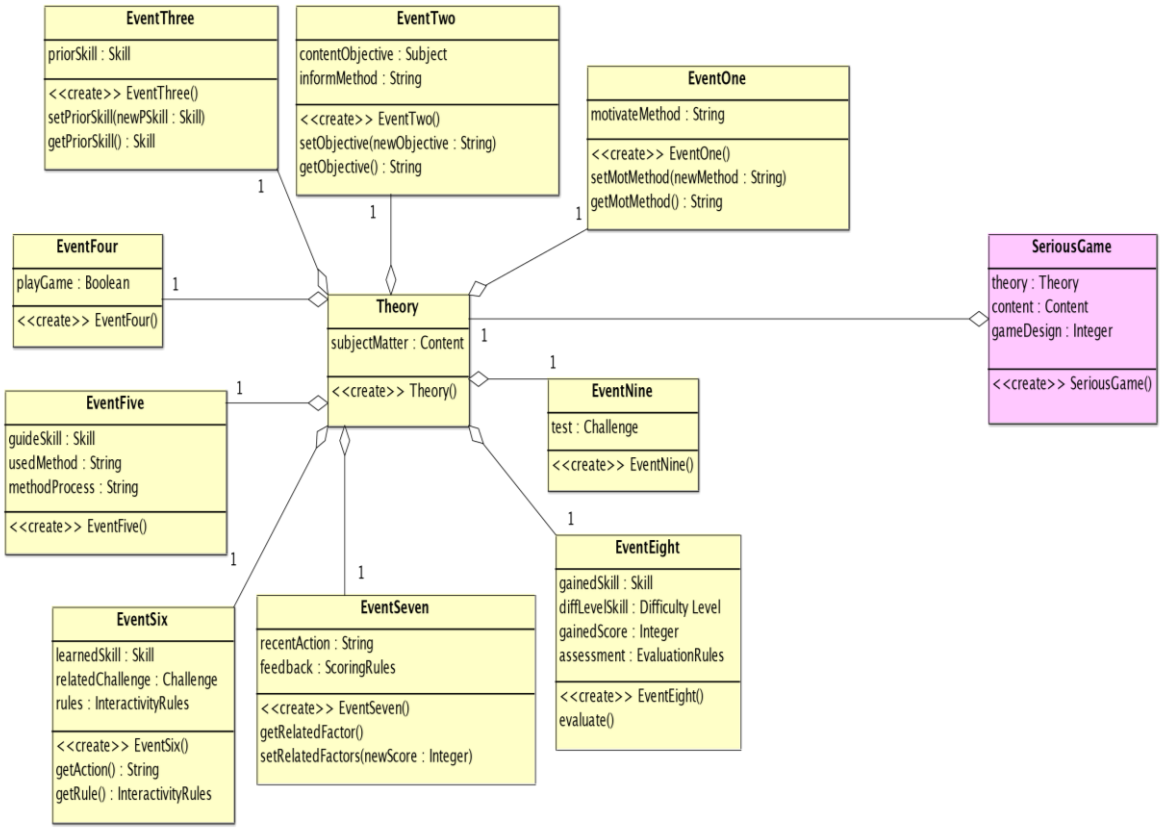

Figure C.2 Theory Components of Serious Games Design Ontology.

Figure C.1 indicates all the components essential for developing a serious game. Different aspects of the serious games are shown in various colors. The theory part of the ontology is indicated by yellow. Color green shows the content part and blue is the game design part. Each class indicates one component. Besides, in this ontology two types of relations between classes are modeled: 1) aggression (a hollow diamond shape) relation which is more like a “has a” relation and 2) generalization (a hollow triangle shape) that is a “is a” relations among classes.

The Figures C.3 indicates all classes belong to the content part. The most general attributes for each class were defined in these classes. However, more attributes could be added according to the serious game.

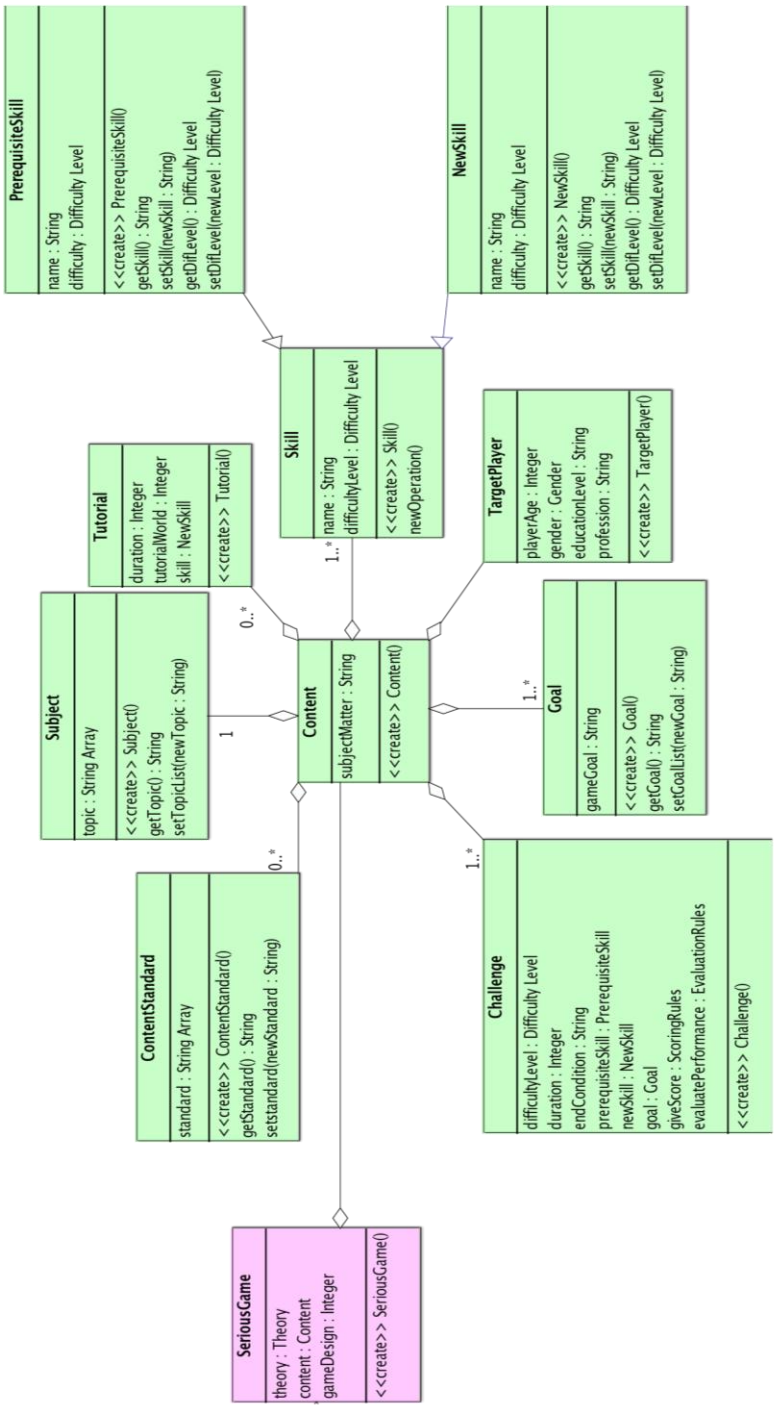

Figure C.3 Content Related Classes Of Serious Game Design Ontology.

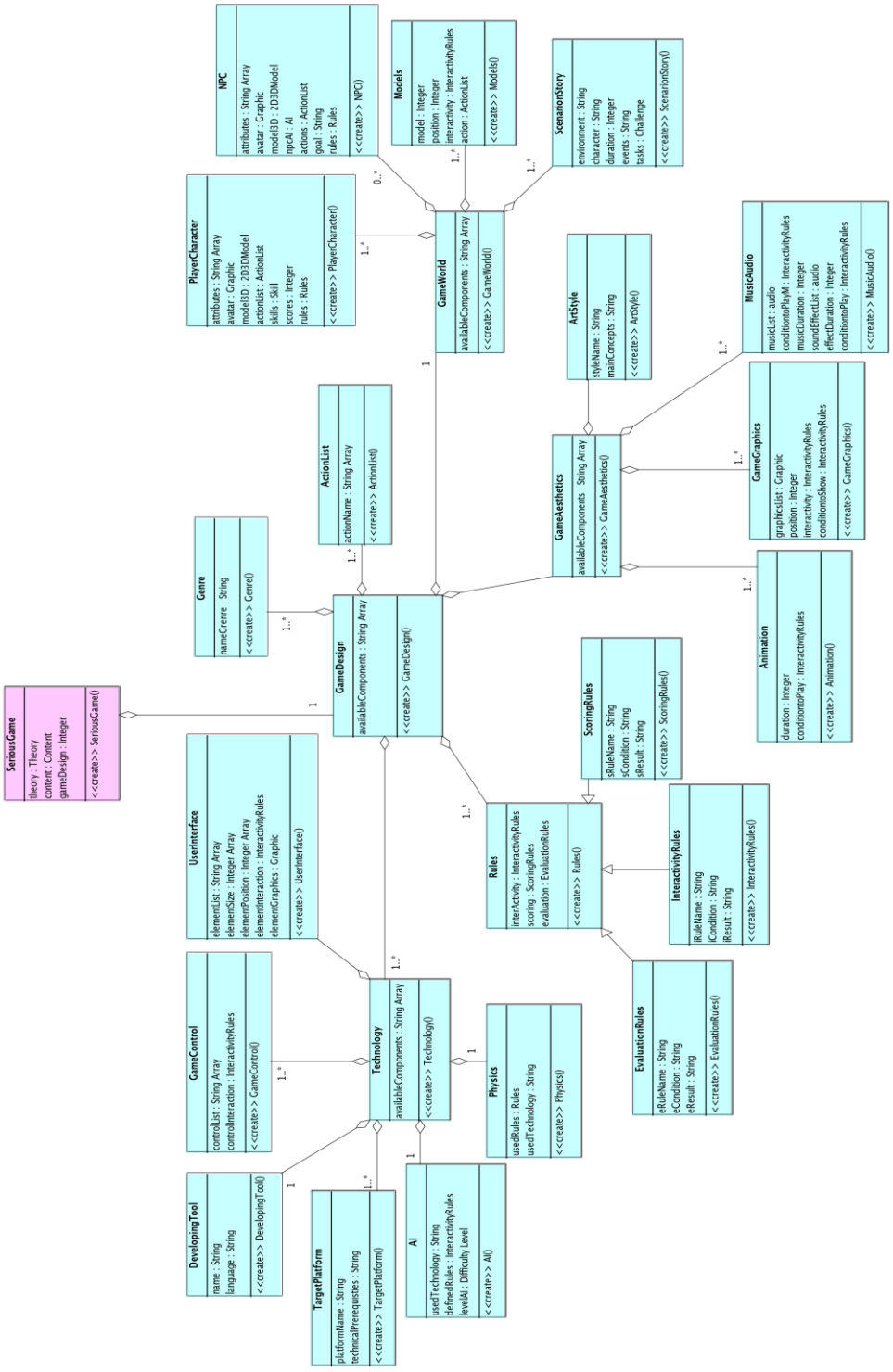

Figure C.4 Game Design Classes of Serious Game Design Ontology (SGDO)

Game design part classes and their subclasses are shown in Figure 4.5. All of these parts will be described in more detail in GATES' ontology part.

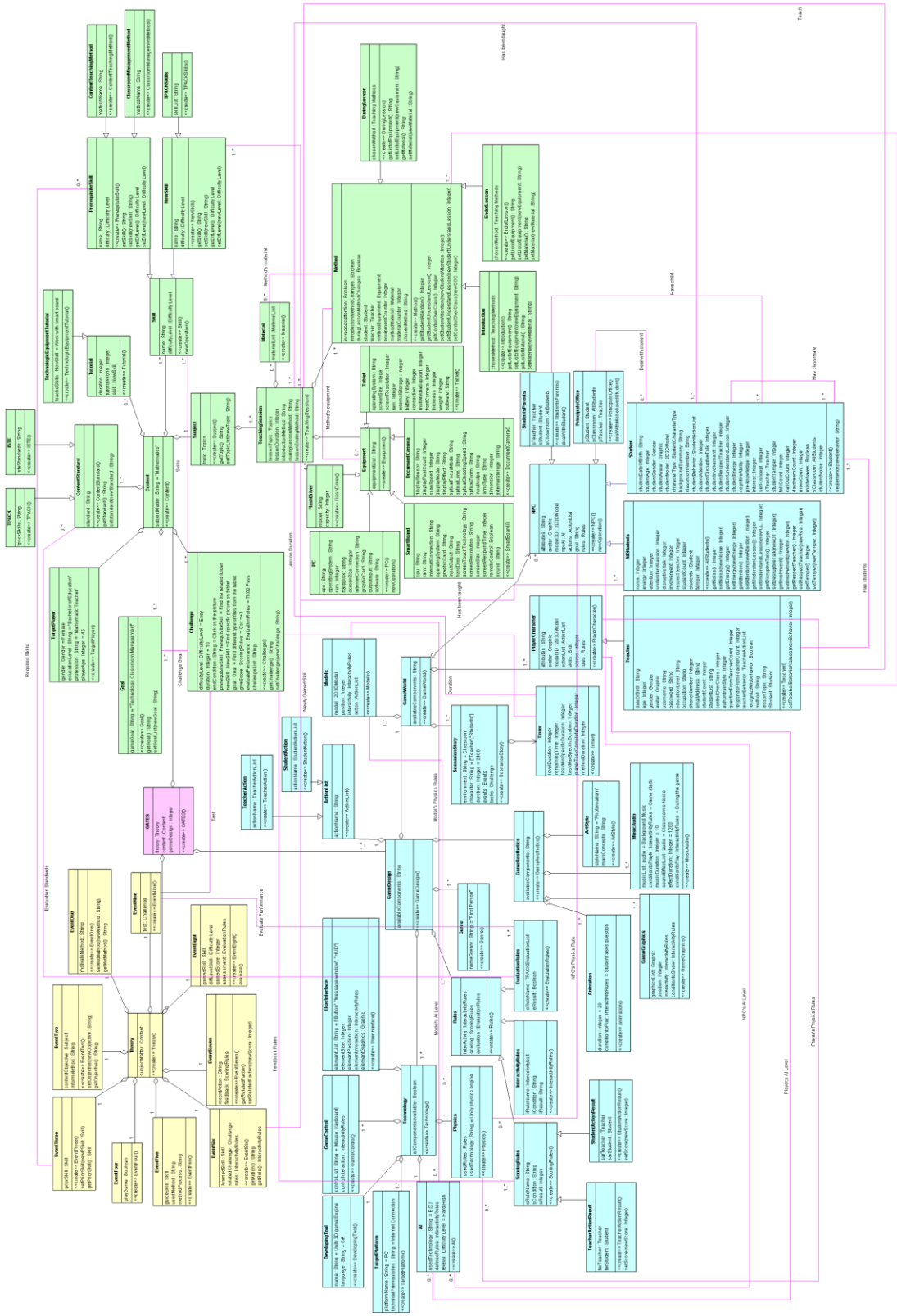

Figure C.5 GATES' Ontology Developed Using ArgoUML.

To develop GATES' ontology, the serious game design ontology (SGDO) was used. As it is obvious in Figure C.5, GATES' ontology, owns all of the classes available in SGDO, it encompasses some subclasses, instances of the classes and their relations. These components will be explained one by one. Since the theory part is the same with the serious game design ontology (SGDO), that part will not be explained.

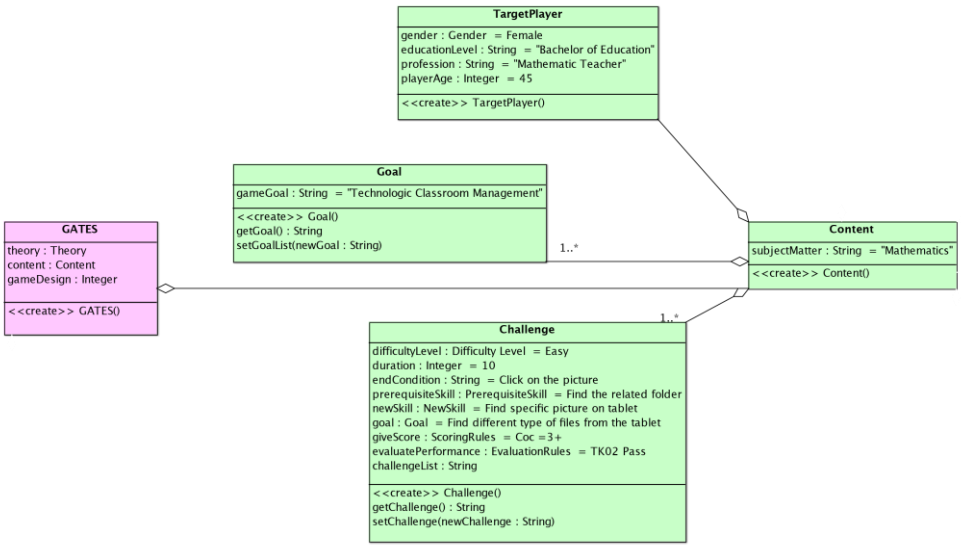

Figure C.6 A Group Of Content Classes Of GATES Ontology.

Figure C.6 illustrates the content classes with their attributes instance values. These values will be assigned according to the serious game that uses this ontology. These values presented, are related to the GATES.

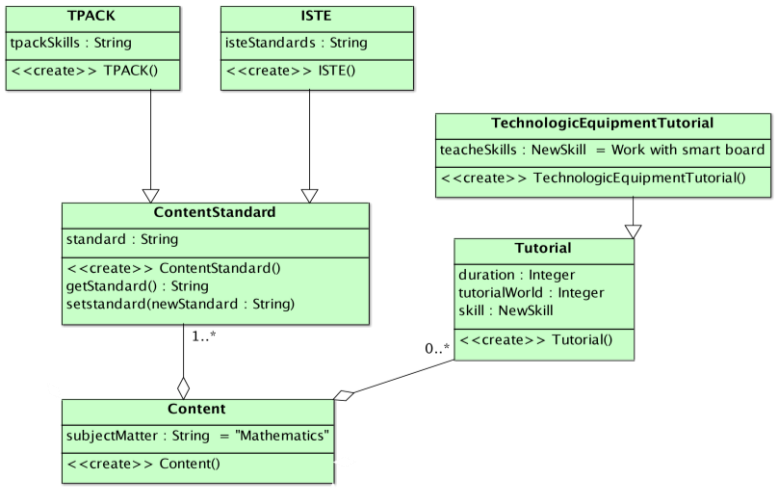

Figure C.7 ContentStandard and Tutorial Classes Of GATES Ontology.

In Figure C.7, different standards that were used in GATES are represented. These standards (TPACK and ISTE) are indicated as subclasses of ContentStandard class. Since the players of GATES are teachers it is assume that they already have information about classroom management skills and the tutorial part just contain methods of utilizing technological equipment.

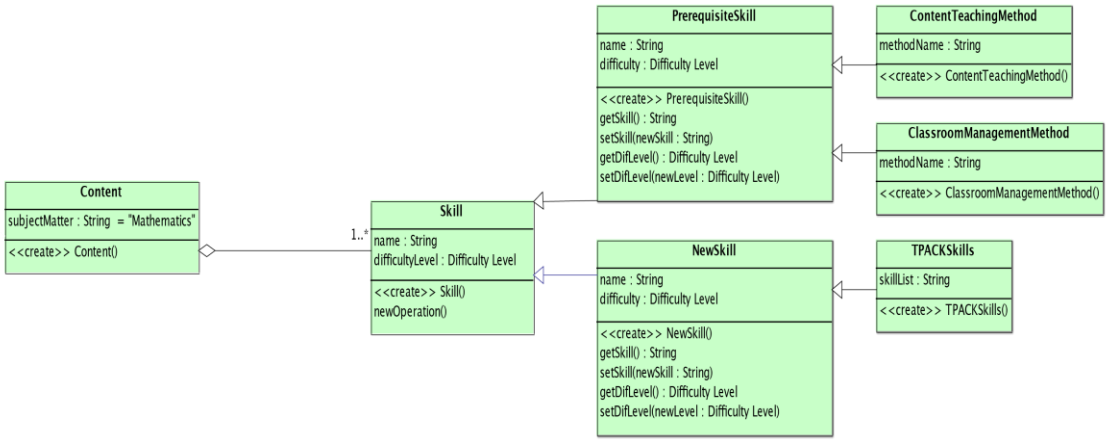

Figure C.8 Skill Class And Its Subclasses In GATES Ontology.

GATES promises to teach its players methods of managing a technological classroom and using technology while teaching atopic of mathematics. These skills are equivalent to TPACK skills. Hence, in GATES new skills, which the player will gain, are TPACK skills. Classroom management skills and content knowledge are skills, which are assumed the players own before playing the GATES (Figure C.8).

In GATES, a teaching session is related to three components: the method player uses to teach a topic, the materials used in that method and the technological equipment teacher get use of to teach the subject. In the ontology all of these are shown using classes and their subclasses. Figure C.9 illustrates all of the mentioned components. According to the developed scenarios for GATES, the methods player can choose among them are categorized into three groups: instruction methods, during lesson methods and end of lesson. For each of these methods there are several materials the teacher can use. Besides, there are several technological equipment available in FATIH [8] project's classrooms that are modeled in the ontology as subclasses of the equipment class. In Figure C.9 in addition to aggressions and generalization, there is another type of relations between classes that are represented in pink. These relation called association and links two or more classes.

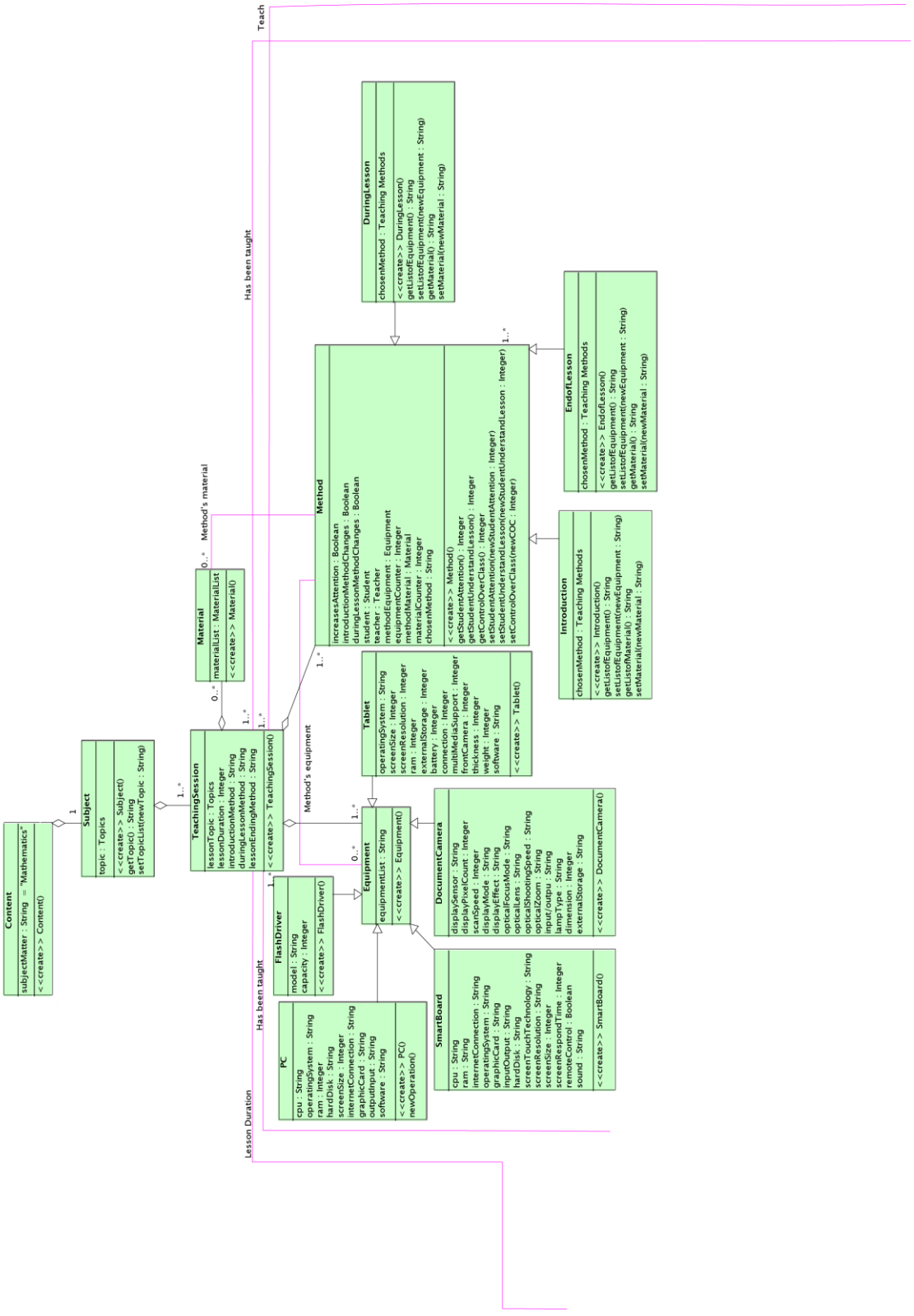

Figure C.9 Subject Class Of GATES Ontology.

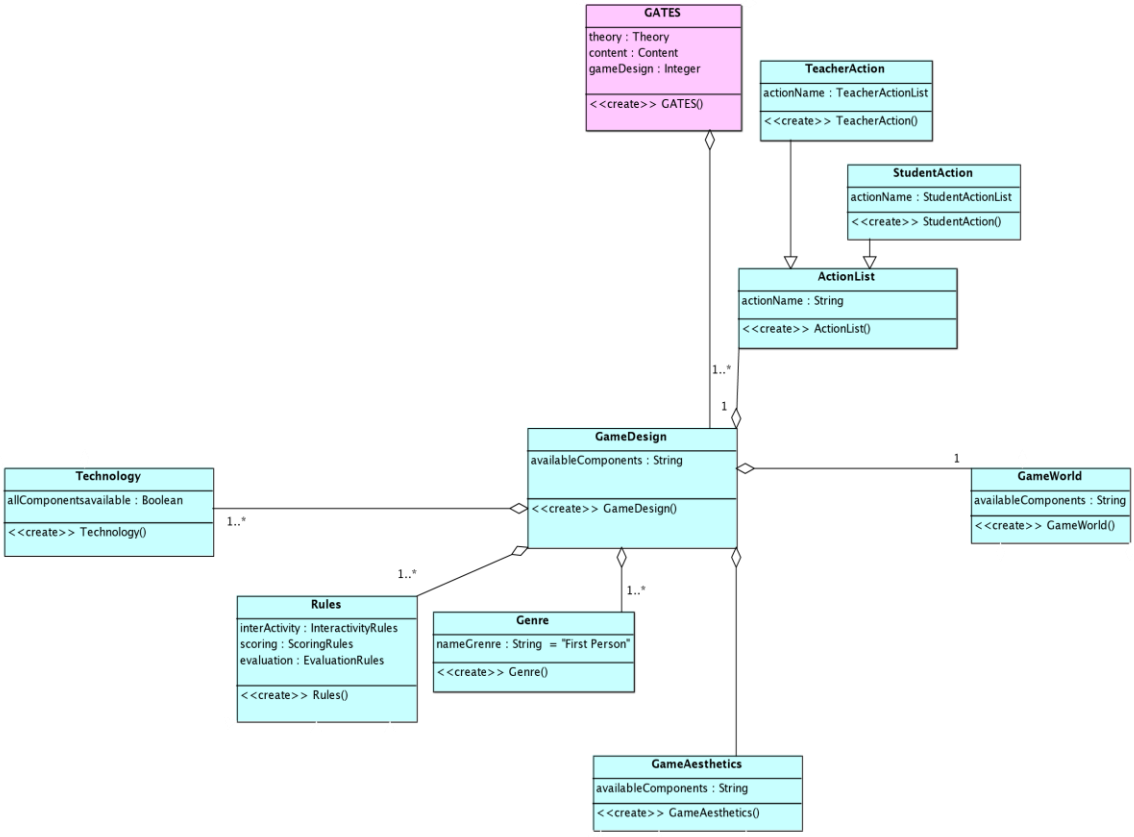

Figure C.10 GATES' Game Design Elements.

Figure C.10 displays all of the main classes of game design aspect of the ontology. All of these classes have an aggression relation with GameDesign class. One of the classes with subclasses is ActionList that is shown in Figure C.10. ActionList contains all the allowed actions in the game. In GATES, just teacher and students have actions and their actions are represented as subclasses of ActionList.

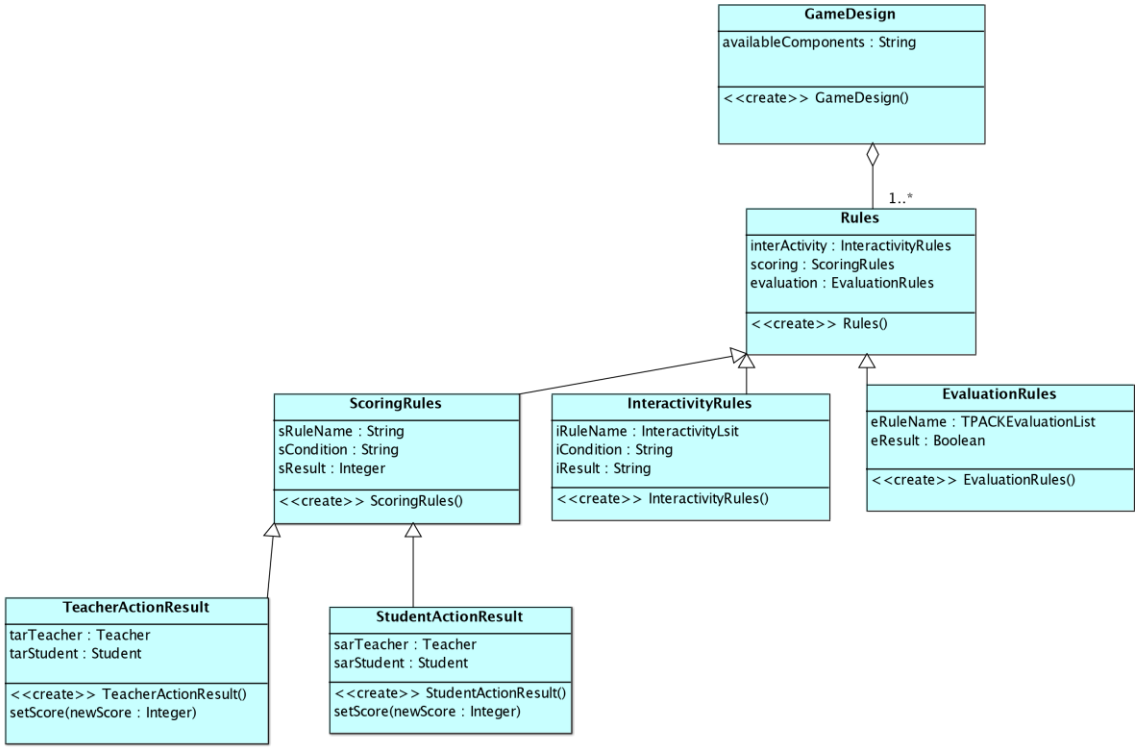

Figure C.11 Different Types of GATES' Rule Sets.

There are three sets of rules in GATES. Interactivity rules indicate the rules about player and the GATES world interaction. The outcome of player's each action will be defined in this group of rules. Evaluation rules contain the rules that are used to evaluate player's performance in the game. In GATES these rules were defined according to ISTE and TPACK. The complete list of GATES' evaluation rules is available in appendix B. The last group of rules, ScoringRules, indicates the rules of feedback system of the serious game. In GATES, there are two groups of feedback rules; one group indicates the amount of the points the player gains after her or his actions. The other group of rules belongs to the students' (NPCs) actions. These rules specify the different situations that the students misbehave. More information about GATES' ScronigRules is available in appendix A. These three sets of rules are shown in Figure C.11.

The components represented in Figure C.12 are related to art part of the serious games. These components result in a more appealing and fun game experience. In GATES like many other serious games, there are various elements related to game aesthetics. Different graphics, various cut scene animations that shows teacher and students' conversations, several sound effects are instances of existing aesthetics elements in GATES.

All the information related to the technology of serious game development will be presented in Technology class and in classes that have an aggression relation with this class. This information about GATES is defined in ontology and represented in Figure C.13.

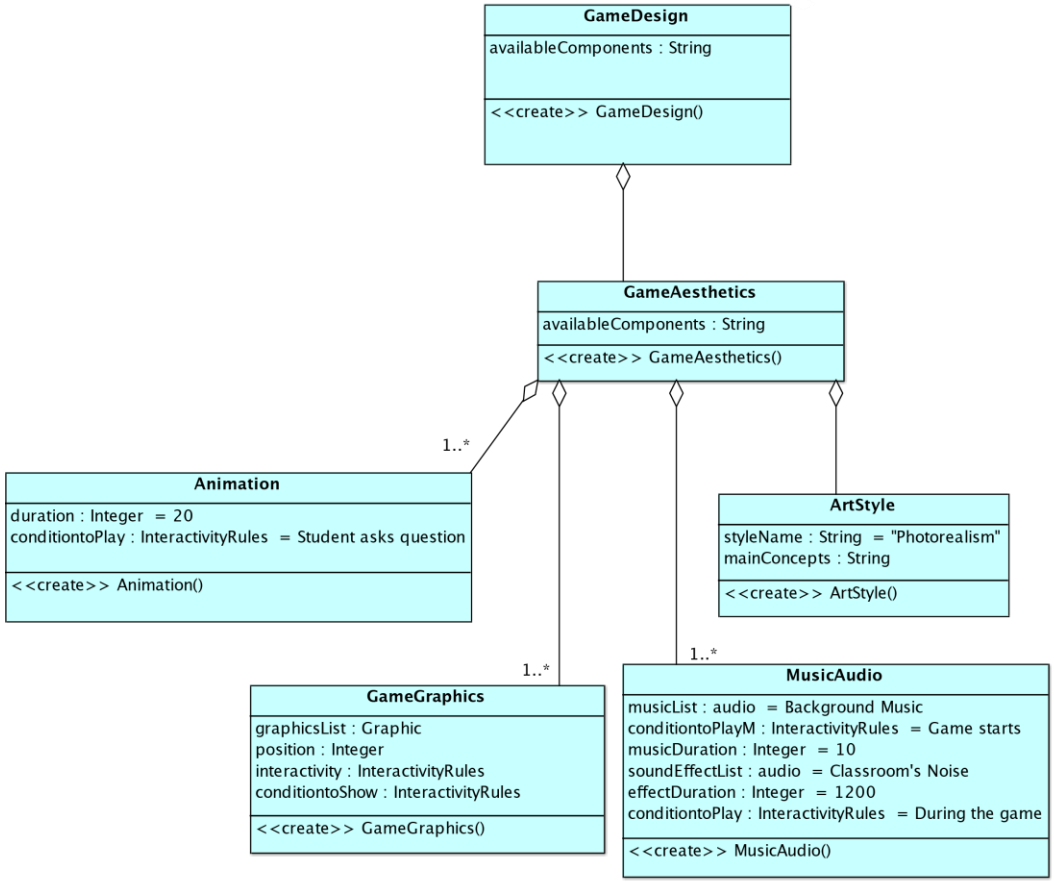

Figure C.12 Serious Game's Aesthetics Components in The GATES' Ontology.

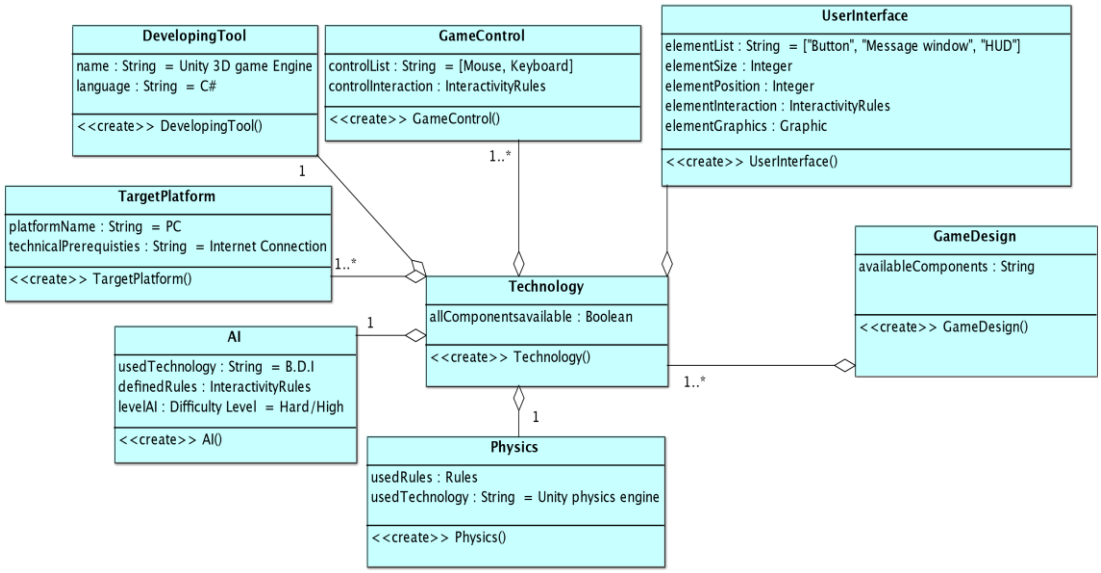

Figure C.13 Technology Related Classes Of GATES Ontology.

The last group of classes in GATES ontology belongs to the game's world that is presented in Figure C.14. One of the most important elements of GATES' world is the player (teacher). Teacher class and its properties indicate every detail needed to model teacher in the game. Two other important classes are Student and All Students classes, which are defined with their every characteristic. At the current time, there are 12 scenarios available for GATES. More scenarios will be added to the game. Each GATES' scenario contains of the flow of events, actions and challenges.

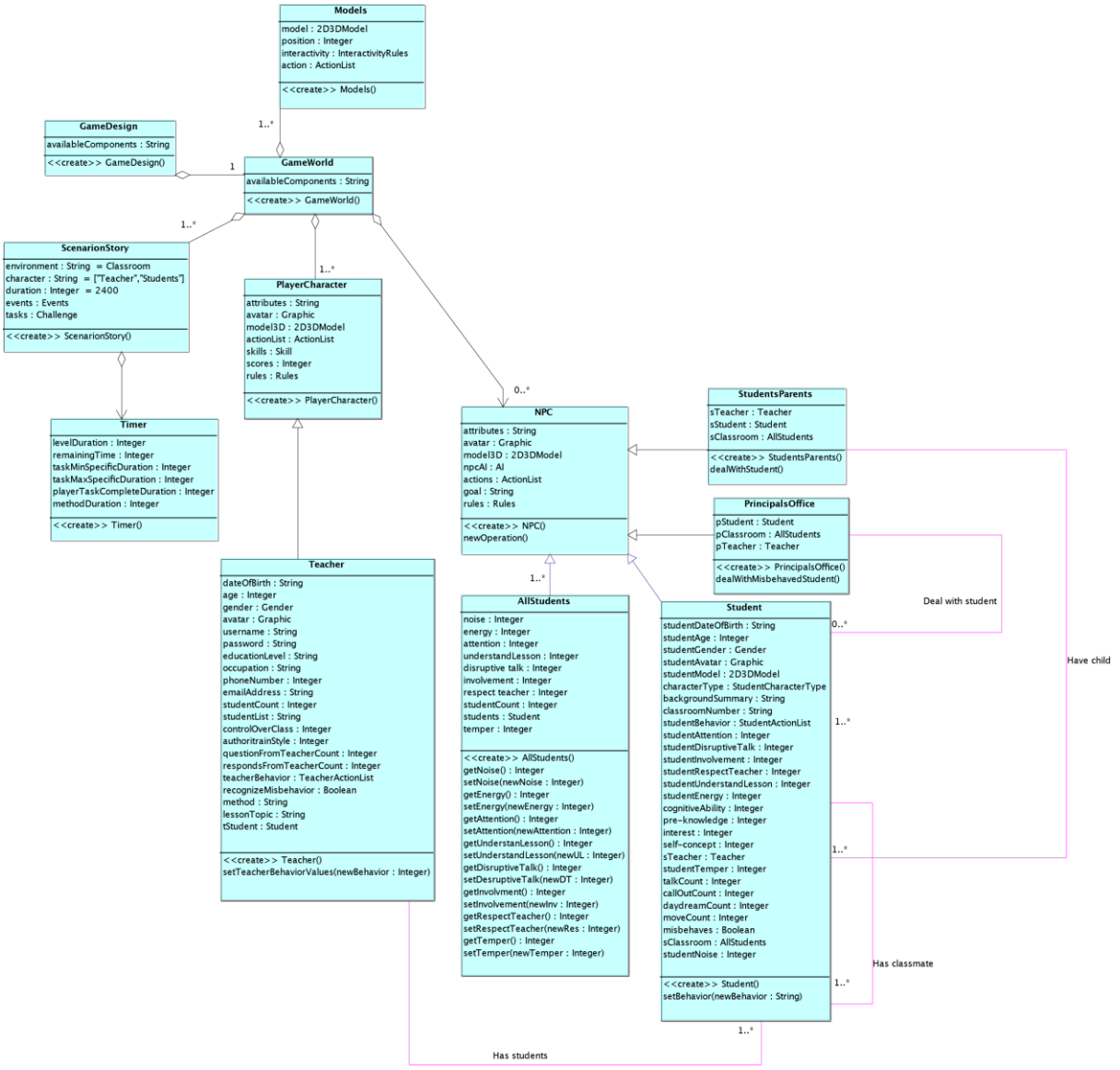

Figure C.14 Gameworld Class of GATES' Ontology.

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : .....
Adı : .....
Bölümü : .....

TEZİN ADI (İngilizce) : .....
.....
.....
.....
.....

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐
3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜdışına dağıtılmayacaktır.) ☐

Yazarın imzası ..... Tarih .....