OPEN – ADAPTIVE – AUTHORABLE PLATFORM FOR EDUCATIONAL GAMES

by

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Abstract

Games in nature are often a bounded simulation of real-world tasks/activities that educate the individual. They are a powerful learning tool not only for the young ages of preschoolers, as F. Froebel described, but for older students too.

The creation of such games demands the need of experts to point out the specifications of a game that targets a specific audience and follow certain standards in order to be productive and understandable by the target audience. On the other hand, teachers have the most creative ideas to apply in simple games and make their students understand basic concepts. This implies an implementation of digital game-based learning in the casual learning process.

Most game creation platforms do not separate the above roles and are difficult for a novice in game creation, as a teacher, to adapt. Furthermore, they do not implement known techniques such as SCORM to make the content or the whole game reusable.

This thesis will study issues concerning the architecture of an open, adaptive and authorable platform were experts will define the standards and teachers will be able to create their games. The interface of the application will adapt to the defined template's needs and to the user's profile.

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Acknowledgements

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Chapter 1 - Introduction

Games in nature are often a bounded simulation of real-world tasks/activities that educate the individual. Baby animals fight with each other of course to entertain themselves but also to get prepared (without knowing) for the real fights in their adultery. Friedrich Froebel, who developed the concept of kindergarten, based the education of preschoolers on playing, singing and performing practical activities. He describes those games as "…a presentiment of the connection between human life and nature, and an indication of the laws of it, so as to give an example - at least a symbol - to live up to." [1]. But game-based learning does not apply only on young students, during the Crusades the game of Chess was used to educate the noblemen about war strategies.

A good example of simulation via games is the game that was invented by Elizabeth Magie with the title "The Landlord's Game" [2] and later published by Parker Brothers as the famous game of "Monopoly". Monopoly challenges the player's management skills and provides a simulation of investment and economy.

Using the current technology of a civilization to advance learning is (and was) common sense. Inventing the stone tools, gain control of fire and inventing papyrus are just some of the primitive technologies that disrupted our life and also education. Of course, not every adaption of technology and techniques benefit education, as Richard Van Eck describes in his talk "The gaming of educational transformation". In the period of Industrial Revolution, the concept of "economies of scale" was embed in education in order to educate many workers with low cost. But by following this behaviorism model, the educational system lacked individuality.

The first association of games and learning was not earlier than the middle of the 20th century when Johan Huizinga, argued that "play is a necessary activity in the generation of cultures" [3]. Digital educational games were firstly appeared in the '80s were video arcades and console games were popular. The first educational game that was ever produced was "The Oregon Trail" from Minnesota Educational Computing Consortium, under the branch of edutainment that was already used for educational films and shows.

Game technology were developing very fast and graphics were getting better and better each year. By utilizing this technology, a new category of learning games emerged, that was providing tools to the player with which he will construct and produce something individual

based on his effort and creativity. Applications such as Logo programming language developed from Seymour Papert, were giving the opportunity to children to develop their own programs. From this mindset emerged the creation of simulation games such as SimCity. [4]

Furthermore, the latest category of educational games are Serious Games that are as well simulations of real-world processes that engage the user in problem solving through realistic variables. Although, those games are targeting the audience over the secondary education. As Mike Zyda defines, "a Serious Game is a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives", [5]

Although the creation of both regular and serious digital games requires game designers, programmers and artists, roles such as educators, pedagogues and psychologists are also a definite requirement for the latter. There are plenty of serious games authoring tools which recognize all or some of the above roles and try to create an environment easy to use and understandable from each of the participating roles. However, the gap between the technical game development roles (game designers, programmers) and the educational roles (pedagogues, educators) is still a major issue on educational game creation.

The research community has developed many models of digital learning ecosystems but few of them put into practice. Nevertheless, all recognize instructors, students, ICT industry and educational content as core entities. As Pettersson [6] refers, there is a gap between the individual teacher and the ICT companies. Teachers are hesitant to use ICT and companies aim to sell directly to municipalities and not individual instructors. This gap has negative consequences on both ICT industry for not having enough feedback and instructors for not having personalized educational content for their students.

This master thesis addresses the following issues: (a) Easy educational game creation and/or parameterization by teachers not familiar with programming, (b) Codification of educational theories and learning models by experts (pedagogues, psychologists) into templates that are reusable and guide the creation of an educational game. (c) Provide a game information template in which the created games can be decoded and compiled in any game engine

Thesis Structure

The next chapter presents the state of the art of educational authoring tools, learning theories and models that are already embedded into the game mindset in order to eliminate the communication gap between the experts of education and game industry as well as to provide mechanisms and techniques for reusable educational and/or game content. Chapter 3 describes IOLAOS architecture, presents its components and explains the connection between them. In chapter 4, we present 2 scenarios of the platform. Firstly, an AEGM-P creation scenario and then the creation of a “Road Safety Game”.

Chapter 2 - Background

In this chapter an in depth research on state of the art authoring tools for educational games will be presented in order to find gaps, limitations as well as unique assets that each one of them has. Additionally, we search through educational theories and learning styles for techniques that are already embedded in games and techniques or theories that provide a common space of communication between experts (pedagogues, educators, psychologists) and game industry (game designers, artists, programmers).

Educational Games Authoring Tools

e-Adventure [7] is an educational game authoring tool created by <e-UCM> research group at the Complutense University. The games are described in an XML format which is compliant with the eLearning standards and specifications. This feature enables the integration of the games in Learning Management Systems (LMS) such as Moodle, Sakai and Blackboard. The type of the generated games is strictly under the point-and-click adventure genre, arguing that story-driven adventure games can be good educational tools as they improve the problem-solving skills and promote reflection instead of action. The platform allows for simple reuse of existing games, and promotes new game development in a cost effective way. The platform provides a language in which the instructors can create their storyboards.

StoryTec [8][9][10] is a desktop application which enables an educational game design team consisted of game designers, artists, technicians, domain experts and pedagogics to create efficient educational games with lower production cost than the usual. To achieve that, StoryTec, integrates the roles referred in one unified authoring tool that visualizes the information inserted by each role and simplifying the game editing by relying on simple concepts instead of programming languages. The platform is based on Unity game engine and inherits the variety of game exports that the engine provides.

An authoring tool for game-based city tours and a rendering app for these tours on iOS. Dividing the tour into stations and connections where connections are the way between stations, this tool lets the author directly map information into the tourist's tour. Arriving at each station can initiate questions or display information to the user, in order to make the tour more interactive and enjoyable.[11]

ARLearn [12][13][14]is a web-based platform for the creation of educational mobile games. This framework is used to create simulations or field-trips which contain media items, progress rules, scoring rules and dependencies between them. A game session requires the definition of users and teams, as well as the assignment of user roles. Each user or team has a specific role in the game. ARLearn has to view modes on the web-based platform. One for game creation and editing and the second for observing the game results from the past sessions. The game can be played in two types of client applications. A google android app which permits playing games in real environment using GPS and a Google StreetView mashup which lets user play these games in a virtual environment. There are also capabilities of interaction between users of those different clients. Furthermore, it can easily be extended with new features and enables third party applications to integrate with ARLearn by implementing Extensible Messaging and Presence Protocol (XMPP, a protocol for real-time messaging) based listeners. The server broadcasts these XMPP messages for instance when a user's score was updated because of an action of a team member, when a new item is visible or to update the location of team members. Below we display a table (Table 1) that sums up the main features of the four platforms presented above.

Table 1 – Comparison of Authoring Tools Features'

Platforms	e-Adventure (2010)	StoryTec (2010)	NoName (Citytours)	ARLearn (2012)
NUIs	NO	NO	NO	NO
Player Interaction Languages	Direct Manipulation (Mouse)	Direct Manipulation (Mouse, Keyboard, Joystick etc.)	Direct Manipulation (touch screen), GPS Location	Direct Manipulation (touch screen), GPS Location
Roles	-Game designers, -Artists, -Instructors, -Player	-Game designers, -Artists, -Technicians, -Domain experts, -Pedagogists	-Creator -Player	-Instructor -Player

Educational Theories	Constructivism, scaffolded learning	Defined by pedagogists	NO	-Situated Learning -Immersive learning -Kolb's learning cycle
Evaluation	Editable by the instructor	Real time instructor observation	NO	Navigation through game results
Created Game Types	-Point-and-Click	-Point-and-Click	-quiz	-quiz, -simulation, -role-playing
Game Authoring Environment	Desktop	Desktop	Desktop	Web-based
LMS Compatibility	Moodle, Sakai, Blackboard	NO	NO	NO
Export type	-eLearning Standard's XML (Learning Object), -jar -android app	Unity Exports	XML (compiled by their iOS renderer)	Mobile App: Google android Desktop App: Google StreetView mashup
Special Traits	-eLearning standards games	adaptation algorithms for the storyline		-Games with augmented reality and augmented virtuality features -Realtime messaging in game with XMPP

Another authoring tool that aimed to decrease the production cost and time is **U-Create**. U-Create [15], a European funded project, was developed to increase competitiveness by significantly shortening production time and effort for content development and to enable non-

programmers to create contents for the intended systems. Interactive stories created using this tool are playable through mobile devices, VR trackers or gesture-based camera interfaces. All the above are either game creation platforms only on desktop (e-Adventure, StoryTec), have no educational background, support a static educational method (ARLearn), are limited to a specific mental disorder (SHARE-IT), or have no educational base, no evaluation mechanism and are desktop (U-Create).

Balancing Education and Entertainment

Educational digital games have a huge versatility of application during the last 40 years including simulations of historic events, real-time emulation of various scenes/ vehicles/ situations, political and business games and many more. Their aim is to familiarize the user with the learning subject using game traits to stimulate engagement. As a result, educational games inherit two inversely proportional variables, educational efficiency and entertainment. Educational efficiency splits into two sections: (a) the educational content and (b) the educational theories that the content will be taught through the game [16]. Both depend on the communication between educators and game industry which have different terminology and point of view. In most educational game authoring platforms, educational content is integrated through mechanisms that are familiar in both domains such as graphs, storylines etc. Storytec [8][9] enhances the intercommunication of the different roles participating in the development team by introducing a unified authoring tool for all roles. In such way, it minimizes the involvement of programmers in most parts of the game development. The information that each role inserts, is visualized into a graph that is comprehensible by all roles. <e-Adventure> [7] also addresses the issue of experts/instructors' lack of technical background by developing an instructor-oriented authoring tool. A graphical user interface, which requires no programming, gives the opportunity to edit the content of existing games or create a game from scratch. By constructing an environment which is friendly for roles that are not familiar with game development, roles such as instructors and educational experts, can provide more educational-based content without escaping the game philosophy.

Parameterize / reuse educational content

Although, there are plenty of game authoring tools developed in the last five years, they do not provide enough flexibility for experts, such as psychologist or pedagogues, to explain and digitize educational theories and learning styles to be reusable in game creation. StoryTec is structured based on educational theories and learning styles such as a model similar to Kolb's Model of learners [17] to categorize the users and knowledge space theory which make games more adaptive and surely educational. However, it does not give space to experimentation with different educational theories and styles. Pedagogues can define the learning path of the game but have to repeat this process for each one they create.

Educational Theories and Learning Styles

There are many different approaches in education, in this section we will refer to behaviorism, constructivism, cognitivism paradigms and the theories that follow those mindsets.

Behaviorism

Behaviorism is a psychology approach that is also used in education. It is based on stimulus-response idea, which means that the subject is rewarded for a right and punished for a wrong action. In this approach internal functions such as feelings or thoughts are ignored and the focus is on actions/behavior. Skinner's theory [17] breaks reward and punishment into two functions: positive and negative. Namely, a positive reward (or reinforcement as he refers) is a way to increase a behavior (e.g. Praise a student/player for his action), while negative reinforcement is referred to the removal of a factor that is displeasing to the student/player (e.g. leaving earlier if all the exercises are done in time). On the other hand, positive punishment is to require more action from the student/player (e.g. by staying after class, or playing the level again), while negative punishment is referred to the removal of a student's benefit when misbehaving.

Cognitivism

The successor of Behaviorism as the mainstream option, Cognitivism, recognizes inner functions as a major contributor to the learning process and need to be decoded and endorsed. Based on the human asset of rational thinking learners have to actively participate in the learning process and reconstruct their schemas (as knowledge is referred in the bibliography). Thus a

replacement, cognitivism, does not completely differ from Behaviorism. It is considered as an expansion that includes the mental state approach of the learner.

Constructivism

Constructivist learning theory suggests that the students learn through exploring and actively participating in the learning process. In constructivism based lessons, the students are given materials instead of plain old textbooks and they are endorsed to explain their reasoning instead of just memorizing facts. Another basic aspect of this learning theory is the social interaction between students by discussing their hypothesis and exchanging points of view. Despite its exploratory nature, constructivist learning process includes also lectures as listening to the tutor is also an active attempt of creating new knowledge.

	Behaviourism	Cognitivism	Constructivism
User Profiling		✓	✓
Scaled Rewarding	✓		✓
Scaled Penalty	✓		
Learner's reviewable progress		✓	✓
User level adjusted challenge			✓
Observation Live		✓	✓
Observation Offline	✓	✓	✓
Examples or Tutorials	✓	✓	✓
Social Networking		✓	✓

Figure 1 - Educational Paradigms' features from game point of view

Combining Games and Education

In order to minimize the communication gap between experts (psychologists, pedagogues, etc.) and game designers we have to find a common language. According to Becker

K. [18] good games already encapsulate components that can be used for instruction and learning. Becker points out that games have already embedded Gardner's theory of Multiple Intelligences which serves as an easy classification system based on social interaction and culture, as well as Gagne's theory on cognitive constructs which divides learning in different levels/ types that require a different instructional approach.

Gardner's theory of multiple intelligence [20]. Gardner proposes eight primary forms of intelligence: (1) linguistic, (2) musical, (3) logical-mathematical, (4) spatial, (5) body-kinesthetic, (6) intrapersonal (e.g., insight, metacognition), (7) interpersonal (e.g., social skills), and (8) naturalistic (sensitivity to natural phenomena, and classification skills). As Becker points out those 8 characteristics are easily recognized as part of any successful game. In order to stress their existence both in game and education we characterize each intelligence module by the skills it represents, its learning and its game values:

1) **Linguistic (or verbal)**:
   (a) Skill: Reading, writing, telling stories
   (b) In learning: Instruction using languages, words, stories etc.
   (c) *In games*: Games often use written and spoken elements to guide the user through the adventure.

2) **Musical (rhythmic and harmonic)**:
   (a) Skill: High awareness of rhythm, pitch, meter, tone and music in general.
   (b) In learning: Instruction using songs, rhythmic patterns or melodies to memorize things (like learning to sing the ABC).
   (c) *In games*: Almost all games use music and sound in general, not only to entertain the player but also as challenge and/or signify change of state (e.g. change state from wondering to battle)

3) **Logical-Mathematical**:
   (a) Skill: Critical thinking, numbering, logic.
   (b) In learning: Instruction using concept analysis, cause and effect concepts
   (c) *In games*: Logic is the most appealing feature of games. The flow of the story, underlying concepts and the immediate response to player's actions (cause and effect)

4) **Spatial (Visual)**:
   (a) Skill: Understanding of space, positioning etc. through vision

(b) In learning:

(c) *In games*: Cameras in games give this aspect a variety of options. Games can be Top View, Side view, etc. (in 2D) and first person, third person, etc. (in 3D) or a combination of them. Players often have the chance to switch between views

5) **Body-kinesthetic**:

(a) Skill: good at physical activities

(b) In learning: Instruction using body movements, acting, making/constructing things

(c) *In games*: Movement in games can either projected through a game controller or, with today's technology, by paralleling player's actual movements through devices that capture motion such as Microsoft Kinect and Asus Action Pro.

6) **Intrapersonal**:

(a) Skill: self-consciousness, understanding of one's strengths and weaknesses

(b) In learning:

(c) *In games*: Games often provide player's virtual characters with which they are immersed into the game. Understanding of the strengths and weaknesses of a virtual character can sharpen self-consciousness and give the player a more analytic point of view in future problems.

7) **Interpersonal**:

(a) Skill: Socializing, exchange of information, cooperation, leadership

(b) In learning: Instruction using constructivism, learning through cooperation and socialization

(c) *In games*: Many games enable players to cooperate and play in the same virtual environment for common or opposite goals. Exchanging information, working together or opposing one another under certain rules is a very lesson its self, simulating the modern society.

8) **Naturalistic**:

(a) Skill: ecosystem awareness

(b) In learning: Walks to nature museums or parks etc. helps the students recognize patterns of the wild life that apply in human society and also develop respect for the ecosystem they live in.

(c) *In games*: Games often provide a simulation of an ecosystem populated by its own flora and fauna in which the player has to use its mechanics to survive, win, explore.

The above 8 intelligence modalities describe skills that we use in our everyday life and can be used individually or in many combinations to provide a joyful but also a good learning experience. As stated from Becker, Gardner's theory has many common assets with Gagne's Nine events of Instruction [21]. In order to find the common space a brief explanation of each of the 9 will be presented:

- Gaining Attention (reception): In order to attract the player/learner we have to use visual/aural/linguistic or other stimuli. Going back to Gardner's theory here we can deduce that each player/learner is intrigued by different stimuli based on their intelligence modules described above.
- Inform Learners of Objectives (expectancy): Quests, missions are the most common keywords for game objectives. Usually players have to complete them to win the game or to learn more about the game scenario.
- Presenting the stimulus (selective perception): Difficulty management is a very crucial aspect of game development. Games utilize techniques such as Vygotsky's Zone of Proximal Development (explained below) to achieve high engagement for long periods of time.
- Providing learning guidance (semantic encoding): Tips, hints, often non-player characters (NPC's) that guide the player through their first step in game but also through their challenges.
- Eliciting performance (responding): Displaying the effects of a player's action is a very nice aspect of games. The player/learner can watch the consequences of his/her choices and actions and gain knowledge in a virtual environment that mistakes are harmless.
- Assessing performance (retrieval): Having specific goals is very appealing for a learner/player. But goal alone is nothing without the feedback! Rewarding the correct action/behavior etc. is a great engagement boost.
- Enhancing retention and transfer (generalization): Games provide the chances to the player to recall and reuse skills gained in previous levels.

A theory also mentioned above, which is common in education and games, is referred as the Zone of Proximal Development by Vygotsky ([22], Figure 2). In this theory Vygotsky describes how difficulty must be distributed in order to challenge the learner/player to keep the motivation and engagement high. Challenge is limited between what player/learner can do without assistance and what player/learner cannot do yet, to prevent boredom from the first and avoid discouragement from the later. Finally, the Flow Theory by Csikszentmihalyi [23], describing the ratio of learner's skills and challenge level in order to keep the game interesting and challenging that are already features of the game creation mind-set, although there are ways of enhancing this feature by using the user profile mechanism to adjust the difficulty of the games.

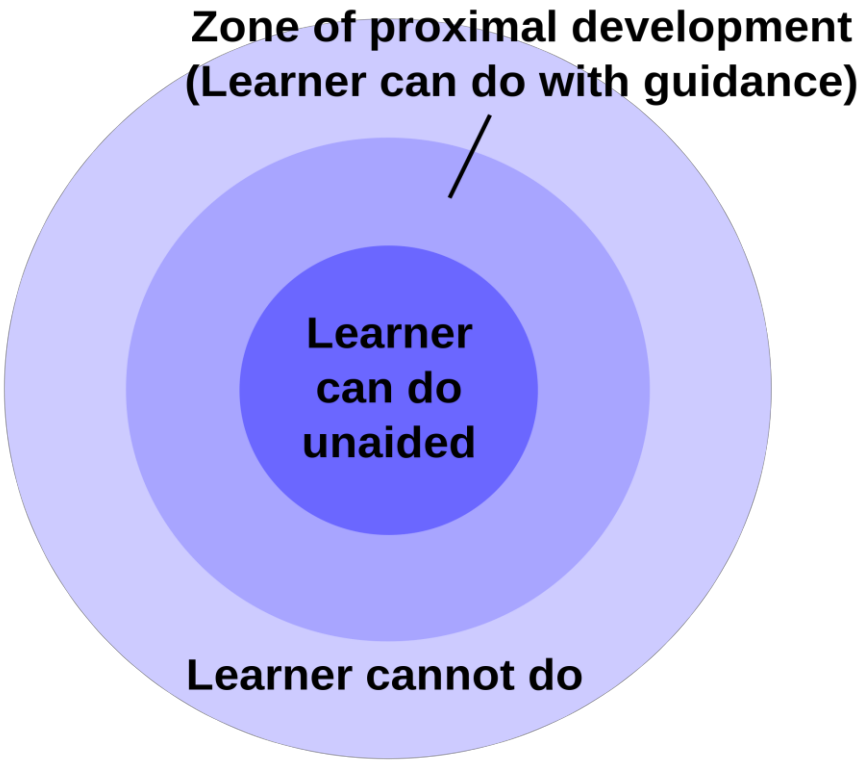


Figure 2 - Zone of Proximal Development

Chapter 3 - IOLAOS Framework

The design of IOLAOS platform [24][25][26][27][28] focuses on setting up the operational model for carrying out the codification of educational theories and learning styles, the generation of ludic, narrative, and educational games according to needs, abilities and educational goals and the evaluation of an inclusive educational session. This design exhibits several novel characteristics, which differentiate an IOLAOS-based game from other forms of educational computer games and platforms. Our approach is not only concerned with educational computer games, but instead, it seeks to provide a guided learning environment for both educators and children, that is story-telling and play-based by combining narrative and ludic for harnessing knowledge. Consequently, its primary focus is to enable educators and children with the use of ludology to perform learning tasks and provide an effective and engaging learning experience.

Architecture

The general architecture of the Open Authorable Digital Adaptive and Ludic platform includes tools and services for (a) enabling experts to codify pedagogics, learner personas, in-game analytics and NUI device data into game guidelines, (b) allowing carers to either parameterize existing serious games to fit specific educational session needs or create their own educational and/or rehabilitation games based on the experts codified guidelines, and the game objects provided by the platform in an easy and without reliance on software developers (c) permit learners to customize games according to their preferences and desires and play games alone or in groups with or without carer's supervision and (d) enable experts or carers to evaluate playing sessions and come to pedagogical and recovery conclusions / decisions as well as allow game guidelines to be updated from in-game metrics and learner choices while playing.

A main role in defining the Abstract Educational Game Model- Protocol (AEGM-P) is fulfilled by educational stakeholders, i.e. experts, educators, carers and learners. Central to the platform is the Common Data Center (CDC), which is a repository for all different types of data such as RDBs, XML, OWL, JSON etc. and supports solutions to gather, store and access the relevant information in a unified way. Around the CDC are all the main modules(see of the architecture: (a) the "Models and Rule Base Module (MRB))", (b) the "Multimodality

Amalgamator (MA)", (c) the "Education – Training Session Module (ETS)" and (d) the "Game Compiler Module(GC)". Several tools and services support the functions of each model. In more detail:

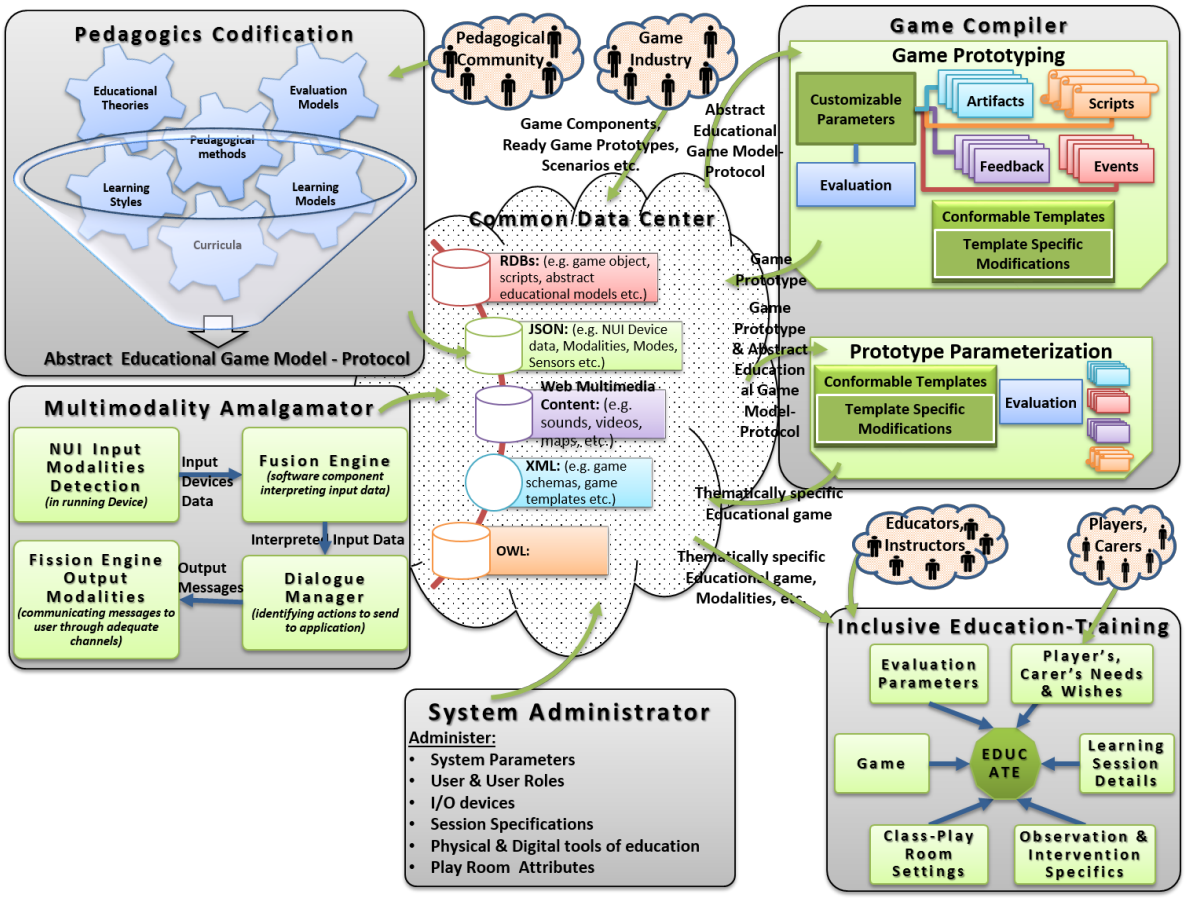


Figure 3 - IOLAOS' Architecture

- **MRB**: include tools and services for sub-ontology of educational theories, learning styles, and pedagogical methods, sub-ontology of learning personas, cognitive and physical limitations, and association to game modifications and an inference engine and API to allow update from in-game and educator interfaces.
- **MA**: provide a device detection mechanism, a fusion engine for interpreting input data and a fission engine for communicating output to the users.
- **ETS**: include tools and services for setting up a learning session in real life conditions, and for observing, intervening and evaluating the educational session. Smart data

analytics will provide information to modify the games to enhance their learning outcomes for individual learners, and to adapt to their varying needs.

- **GC**: includes tools and services for creating serious game prototypes according to educational, learner and real site specifies. It also includes tools and services for personalizing the game prototypes to fit educational and user needs.

Models and Rule Base Module (MRB)

MRB is a module that enables experts such as pedagogues and psychologists to digitize already existing but also new educational theories into Abstract Educational Game Models – Protocols (AEGM-P) in order to guide game creation. The interface as well as the actual AEGM-Ps are constructed based on the common space (theories, techniques, etc.) between psychology, pedagogy and games such as theories of Gagne, Gardner, Vygotsky etc. By using this common space, experts can fully describe educational theories in compact autonomous entities, stored in our platform, which can be easily used/reused by game designers and give enough information without communication problems caused by missing knowledge from each other's field.

AEGM-P's structure as mentioned previously is based on the common information space between games and education. The model can be separated in 4 main groups of information: General Info, Output, Input, Game flow.

General info contains indexing information such as a name, educational theories and learning styles on which the template is based upon, target age and target special abilities (if any). Furthermore, additional information is also saved on this group such as creator's name, last modification date etc.

Output group contains information about 3 main output categories visual, aural and haptic. Visual aspects of the game refer to the range of colors and the use of textures as well as the motion of sprites on the screen and their animation. Aural output refers to game sound. Namely, sound effects, background music but also features that can be used to enhance the game usability such as text-to-speech. Lastly, haptic contains vibration which can be used in various ways inside games, by giving clues or giving warnings.

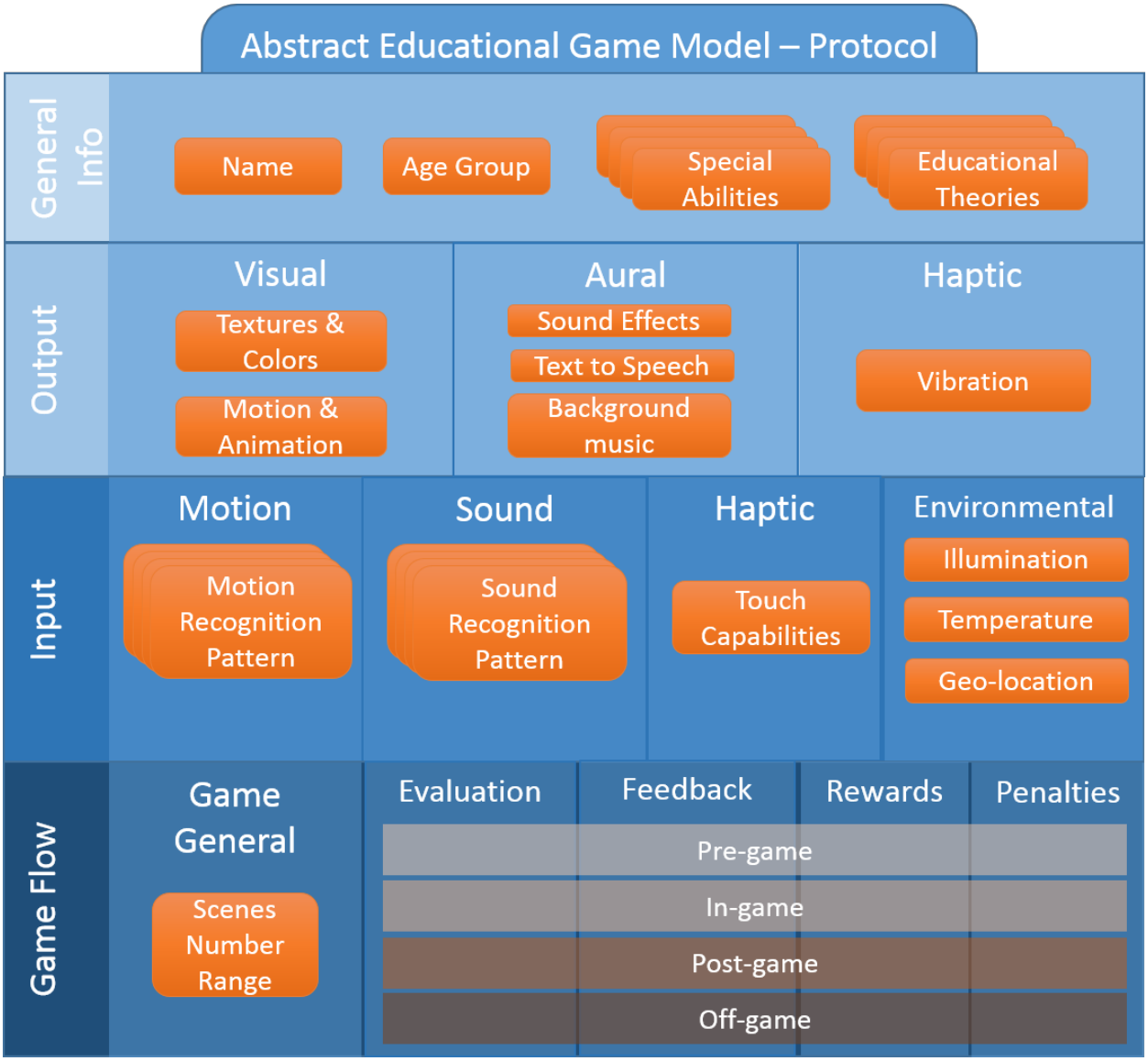


Figure 4 -Abstract Educational Game Model – Protocol (AEGM-P) structure

Input output group contains 4 main categories: motion, sound, haptic and environmental which refer to the sources that the game captures to use as input. Motion has a set of different motion recognition patterns from head to toes utilizing various devices, from a simple web camera to a Microsoft Kinect sensor. Sound contains complex recognition patterns such as speech, ambient sounds or as simple as measuring the ambience sound level. Haptic group encloses only touch screen. Lastly, Environmental group consists of measurements of the player's environment such as temperature, illumination and geo-location.

The last group, Game Flow has 5 subcategories: Game General, Evaluation, Feedback, Rewards and Penalties. The first, Game General, only contains the range of scenes allowed for the game to contain. The rest of the subcategories' features have been divided based on the game flow. Features that are utilized before game starts refer to as Pre-Game, during game as In-Game, after the game as Post-Game and those that are independent of the game and must be performed out of the game (as giving an apple to the student) as Off-Game features. Feedback group contains techniques to warn, inform or instruct the player. Rewards group encloses techniques to recompense the player and Penalties to techniques to "punish" the player (punishment is mainly included in the platform for behaviorism patterns to be fully described). Lastly, Evaluation contains synchronous as well as asynchronous ways of observing the players progress and evaluating the game's results.

Features are stored into a relational database. Importantly, the platform supports the addition of new features in the AEGM-P. Common Data Center provides services to store, and fetch AEGM-Ps using JSON format. Those protocols are used in Game Development process through Game Compiler but also at game play to adjust the game input and environment to the target group of players.

Game Compiler

Game Compiler is the game creation/editing service of IOLAOS platform. It consists of two main sections: Game Prototyping and Prototype parametrization. This tool addresses game designers as well as educators/instructors. An individual can either create a game from scratch or parametrize an already existing (in our database) game so that it fits his educational goals. It is responsible for providing the "Educator" with the necessary tools to set up a ludic educational game. In other words, it gives the "Educator" the possibility to (a) customize the generic template set up by the "Expert" at the "Template Codification" component in such a way that suits the specific game requirements according to target user group abilities and educational goals to be achieved, (b) create a ludic game with the use of the tools provided by IOLAOS platform and (c) to define game utilization parameters such as: Free Use, Registered User Only, etc.

Game creation process starts by choosing the AEGM-P on which the game will be based upon. This way the game editor reconfigures its user interface and capabilities, as well as the

textures/sprites/scripts that are available in its stash to fit the need of the selected Model-Protocol. Scene number, colors, evaluation, feedback, frame rate etc. are all within the boundaries that an expert has described so that the game's educational value will remain high.

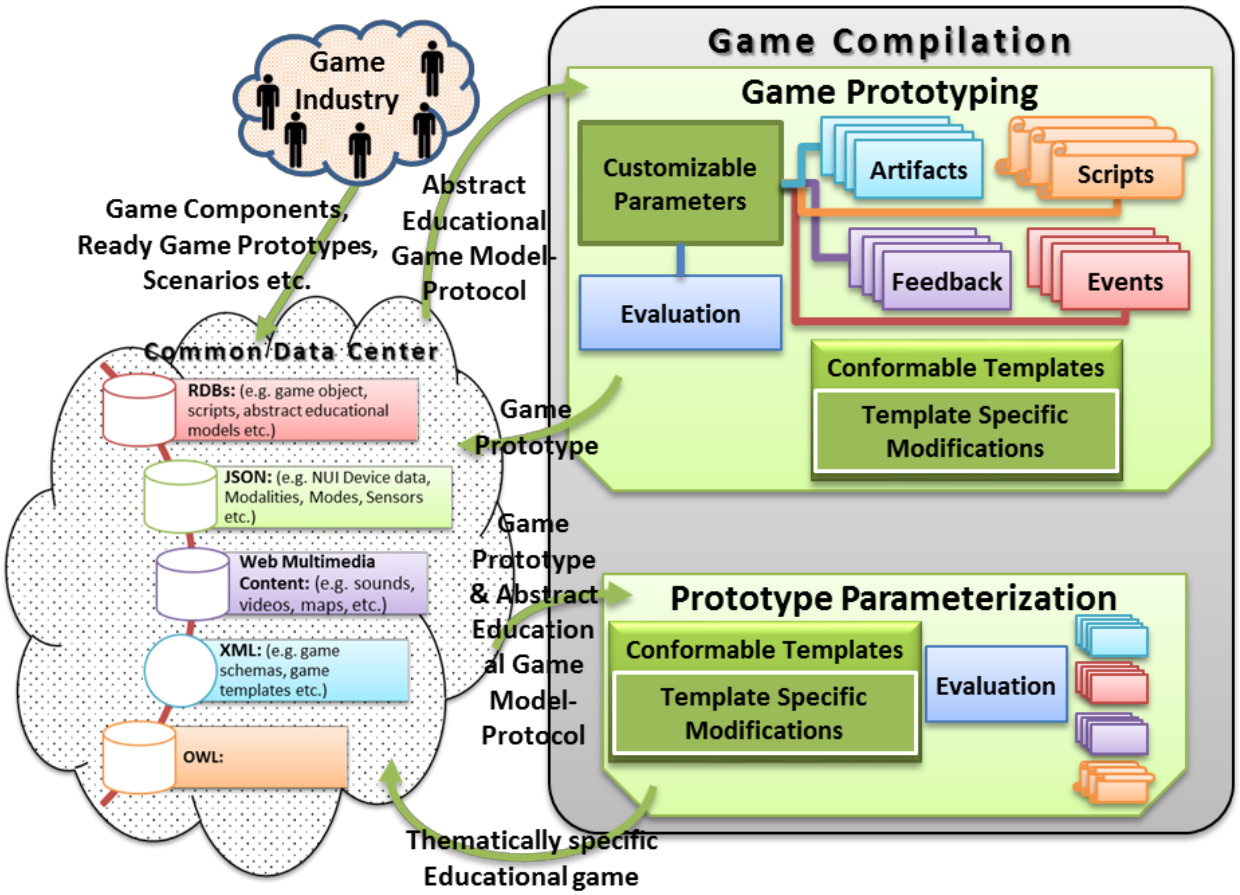


Figure 5 - Game Compiler

The construction of the game is drag and drop based and no programming skills are required in order to create simple yet entertaining games. As figure 4 shows, games contain artifacts which can be sounds, images, sprites, videos etc., scripts that give interactivity and abilities to the artifacts, events created by the scripts and used to initiate other scripts, feedback that can be visual, aural or anything that has been allowed on the selected AEGM-P and evaluation patterns based on the events that the game creator wants to observe.

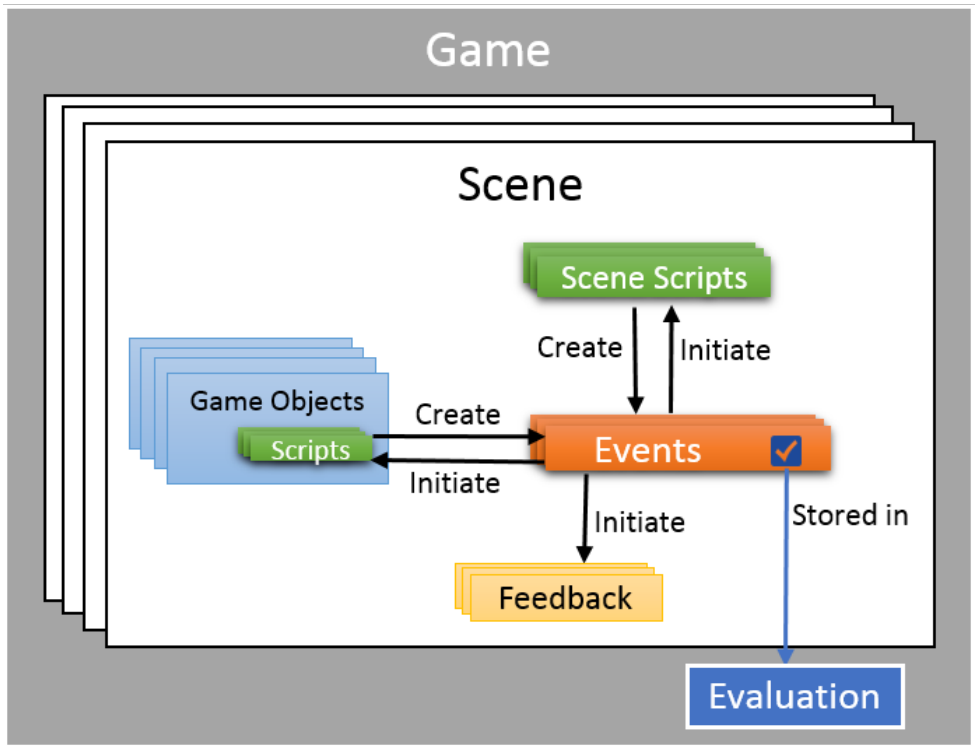


Figure 6 - Game Data Structure

Created games data are stored with the structure that is described in Figure 6. Each game is a set of scenes that contain game objects, scripts, events and feedback. Each game object has a set of scripts that trigger or been triggered by events. Scene has also general scripts that refer to game flow and general events. Feedback is also triggered by events created by game object scripts or scripts of the scene. Each event has the option to be stored, when triggered, for evaluation purposes. Educators can edit already created games or create new from scratch.

These games structures are stored as a JSON file in Common Data Center and are recalled when the Educator creates a new game session (through the Inclusive Education – Training component).

Inclusive Education – Training

With this module our platform provides the educator with the ability to fully manage learning sessions according to individual, group or class requirements every time she/he needs to run an educational game. This module has several aspects and viewpoints. Teachers enable game sessions, with or without live observation and data storage features, they initiate game sessions and invite students to participate. Session manager distributes the game data to every invited student that joins and establishes a connection with the clients in order to receive game

information and handle communication between players and the tutor. Students get into game from their devices, load the game data and start playing the game. The controls of the game are different based on the users' client device or can be strictly specified by the teacher on the prototype parameterization state. More specific the educator can determine, (a) Players and/or Group, (b) Marking / Evaluation Specifics / Procedure, (c) Session Statistics, and (d) Session parameters. She/he can also interrupt and save learning sessions in order to be completed in the future. While running or after the game session tutors can evaluate players' performance through live observation (watch player's screen) or game statistics which are based on events that are set to visible for evaluation. Lastly, player's score and performance are stored into his/her profile for future use, either for the player (watch his/her progress) or the tutor (watch progress and/or adjust the next game's difficulty). Game controls as mentioned above differ from device to device, this is based to the last module of our system Multimodal Amalgamator.

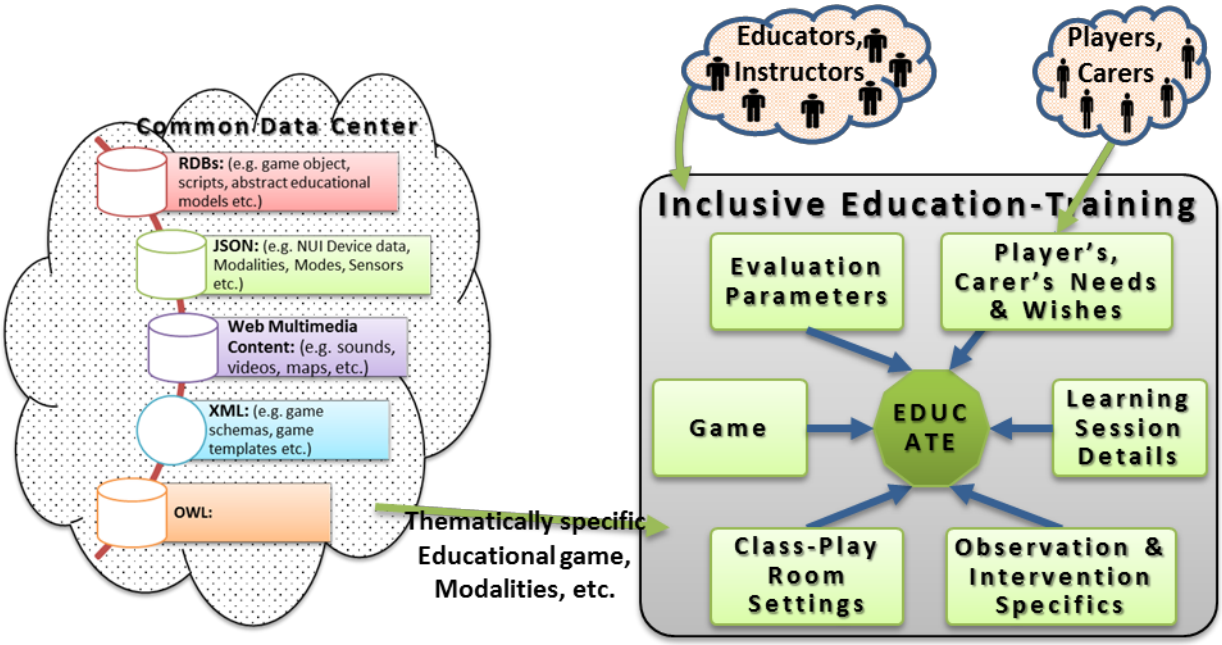


Figure 7 - Inclusive Education-Training

Multimodal Amalgamator

Multimodal interaction systems aim to use naturally occurring forms of human communication as a way for human computer interaction [17]. In our system, the "Multimodality

Amalgamator" component (see Fig. 1 and Fig. 3) uses modalities with very different characteristics such as speech, hand gestures and body movement, in addition with more commonplace input methods, in order to allow the user to have a more natural interaction with the application.

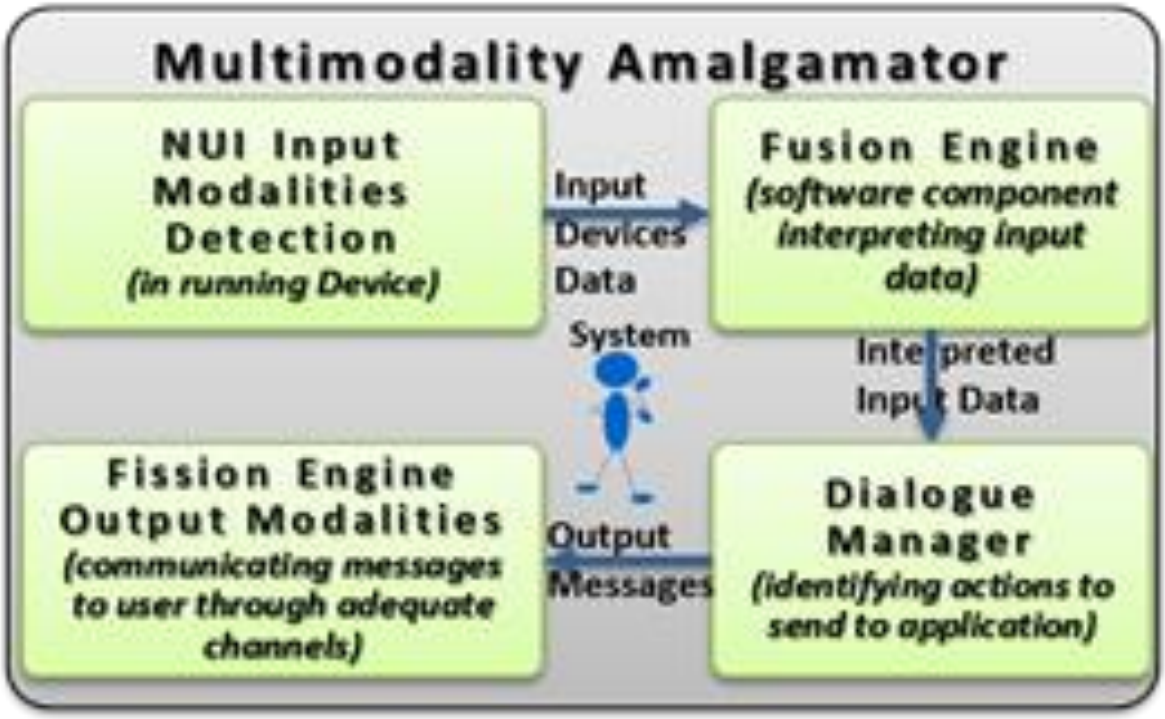


Figure 8 - Multimodal Amalgamator

The "NUI Input Modalities Detection" sub-component perceive input modalities through the appropriate input devices (e.g. microphone, web cam, etc.). Its results are then passed to the "Fusion Engine" sub-component, a software component responsible for providing a common interpretation of the input data. The various levels of which the data can be fused is beyond the scope of this paper. When "Fusion Engine" reaches an interpretation, it is communicated to the "Dialogue Manager", in charge of identifying the action to communicate to the given application, and/or the message to return through the "Fission Engine Output Modalities" sub-component. The "Fission Engine Output Modalities" is finally in charge of returning a message to the user through the most adequate channel of communication (output modality), depending on the user profile.

Chapter 4 - Implementation of the authoring tool

As mentioned before IOLAOS is a multiplatform framework. In order to achieve this, we had to utilize different technologies that are compatible with a wide range of devices. In this chapter we will refer to the technologies that were used to create the platform as well as the final product. For the first implementation and for the proof of concept, we choose to focus on 2D games.

Technologies Used

Liferay Portal

Liferay Portal is an open-source, easy to use content management system that provides multiplatform compatibility, already created basic features for your site as well as a robust framework to edit or create new. It provides a unified document repository in which media such as video, audio, images and other types of media can be stored and recovered by tag or by file type. Its active community helps the newcomers understand the framework (with videos, documents, tutorials, forums etc.), but also corrects quickly any bug or malfunction occurs. For the purposes of user data history of our platforms players, we enhanced the authentication system of Liferay to keep more information for the player as is his/her special abilities, class, achievements etc. Liferay uses HSQL or "hypersonic" as default database management system but MySQL were utilized for IOLAOS platform.

Bootstrap 3.0.0

Bootstrap library were used to create responsive UIs in all IOLAOS' platform tools. Bootstrap speeds up web development with already made design patterns and a well-organized grid system that uses classes to define the relative width of each element. It provides UI elements and widgets such as panels, wells, modals, buttons, thumbnails, badges, form validation and many more. It supports most of the mobile as well as desktop browsers. Namely, it is compatible Chrome (Mac, Windows, iOS, and Android), Safari (Mac and iOS only), Firefox (Mac, Windows), Opera (Mac and Windows) and IE8+. Moreover, Bootstrap also provides a great set of prefixed glyph icons but also the compatibility of adding external libraries. Lastly, its

JavaScript snippets help a lot on improving the interface and make the site's functionality fluid in the eyes of the user.

JQuery

JQuery enables easy interaction and editing of DOM elements but also methods for Ajax, event handling and animation. It is compatible with most of the browsers. In our platform JQuery were used for custom form validation, custom styling of certain DOM elements and the construction of game data JSONs on game editor. JQuery were used through almost all of the website for styling, workflow and interaction purposes.

Turbulenz Game Engine

Turbulenz is an HTML5 game engine that provides several features for easy and quick game development. It has 2D as well as 3D capabilities using WebGL graphics, physics for both dimensional options and also sounds and easy debugging. Moreover, Turbulenz provides networking features for online multiplayer or any other networking process like uploading score, online game save etc. It also provides a server in which you can host your game and can handle all the multiplayer traffic.

We use turbulenz game engine into the game editor's canvas for real-time construction of the game scene. It provides easy to use listeners and methods to render the dropped items into the canvas, as well as easy item feature editing.

Phaser Game Engine

Phaser is also an HTML5 Game Engine although with a different approach. Phaser is more flash – like, dedicated to 2D but providing powerful tools. It provides two different physics engines (Ninja and P2) that include methods for realistic movement in order to enhance the user's experience.

We used Phaser game engine as a second game engine to prove the concept of unified game data (into a JSON file). The product JSON from game editor can be translated and recreated from any game engine that has at least a physics engine and 2D capabilities. Phaser is used for our preview tool embedded into the game editor. It translates the produced JSON into playable game to help the tutor test his creation.

Representative Scenarios

To illustrate some of the concepts described so far and to provide insight into the Educational Game Creation Tool, we will describe 2 representative scenarios emphasizing on each role's workflow. Through this process we will show you the whole timeline of game creation (see Figure 9 - Game creation timelineFigure 9), although because of the platform's asynchronous capabilities this order is not strict (given the fact that there are already stored components in the platform's database). Our reference scenarios are summarized in Exhibit 1 and 2 and are part of the game creation timeline that is shown in Figure 9. In more detail, Exhibit 1 refers to the creation of an Abstract Educational Game Model – Protocol by an Expert which is the first part of the timeline (Figure 9). Exhibit 2 refers to the creation and play of a game which is the second, third and fourth part of the timeline (Figure 9) and is performed by the Instructor in our scenario.

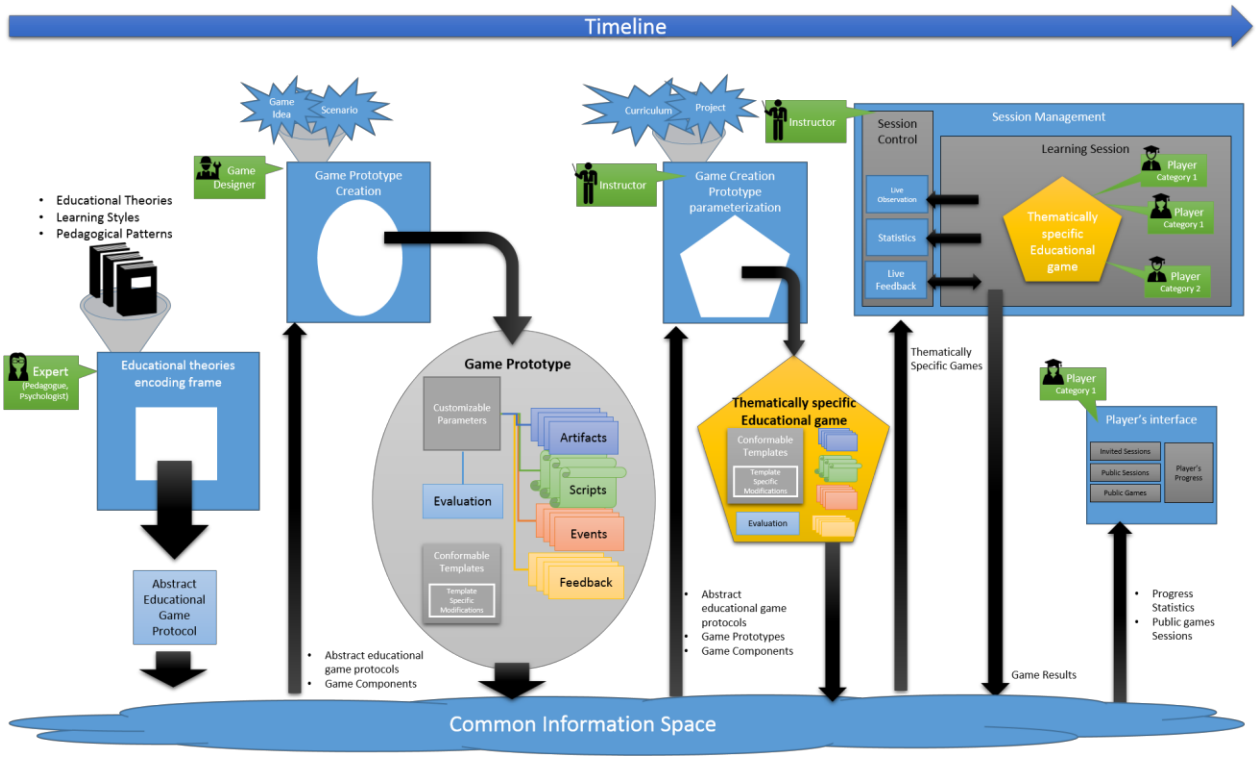


Figure 9 - Game creation timeline

Scenario 1

Exhibit 1: For the first scenario an Expert wants to digitize a mix of learning theories in order to store them into our system. The theory that he wants to include to his AEGM-P is Situated learning. Situated learning theory (Reference) refers to learning through communication and hands on experience of the learning subject. This technique includes roleplaying to simulate real world problems and also visits to the actual places that the subject is referred to. As mentioned before, situated learning is based on communication. Collaboration and interaction between students is a key factor and must be endorsed. Situated learning is dilemma driven and challenges intellectual motor skills of the student. It focuses mainly on the process of learning through an activity rather than the product of it (e.g. the process of making a project through all its states is more important than the actual product). In this example the target group of students will not have any special abilities and the age group will be wide, targeting any age.

AEGM-P Synthesis

Expert starts the creation of AEGM-P by adding the general information about it. Name, Based on (theories), target special abilities, and target age (or grade) will be used as keywords to later when the educators want to find the most fitting Model-Protocol for their game. Also, a short description is given, so that the user of the AEGM-P will understand more about the digitized technique.

In the second step the expert sets the variables of 3 basic output types visual, aural and haptic which are also referred as 3 out of 8 primary intelligences in Gardner's theory of multiple intelligences. In this example the AEGM-P does not refer to a special ability such as autism or ADHD so there are no restrictions in color and motion inside the scene. There are also no restrictions on sound and expert has enabled vibration as an additional output option, which as we have seen in game consoles, is a great way of adding action to the game. As soon as Learning Styles' Specification is ready, the expert, presses Next Step to move on to Game Input.

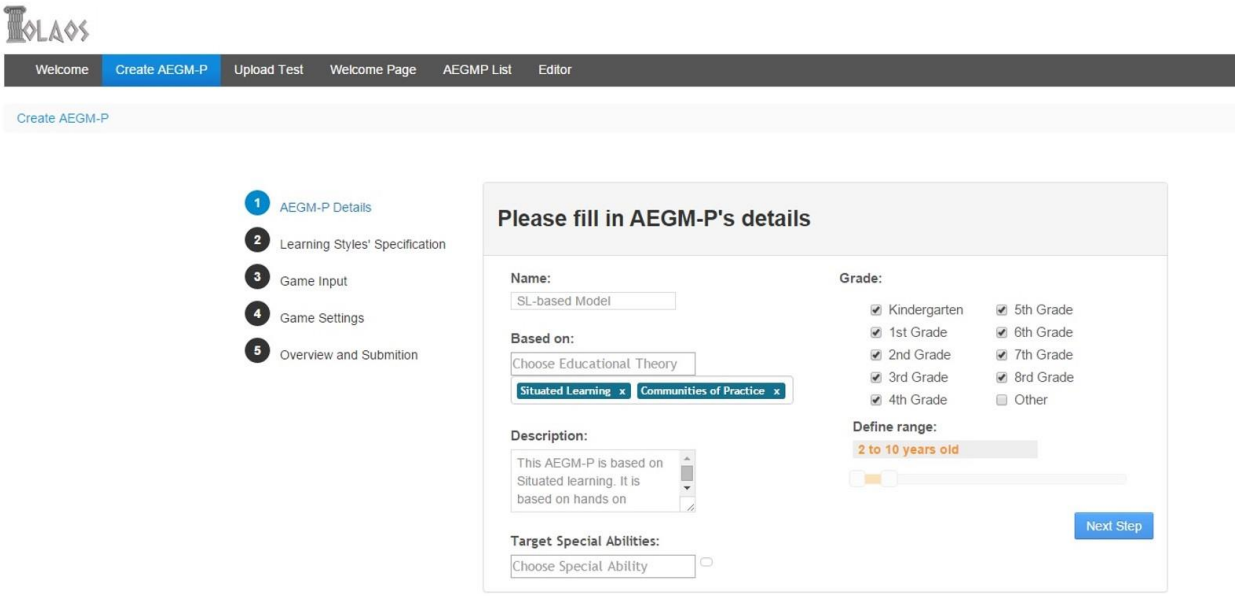


Figure 10 - AEGM-P Synthesis Step 1: AEGM-P Details

Game input refers to which ways will the system provide to the player in order to control the game. Motion refers to anybody motion as head tracking (including: Eye tracking, lip tracking, facial expressions recognition and head tracking), Upper Body Tracking (including: finger tracking, hand tracking, arm tracking, upper body movement tracking) and Lower Body Tracking (including: Leg tracking and Step counter). Secondly, expert sets the sound recognition patterns that games can have, such as speech, ambient sound or sound level. For now, haptic patterns contain only touch screen as input, but as stated before, IOLAOS platform can assimilate new features for AEGM-P as the already imported could not be sufficient. Lastly, as environmental inputs, there is Illumination, Temperature and Geo-location. It must be noted that checked recognition patterns do not obligate the game creator to use them but give him the freedom of using them. A game can have an AEGM-P that has all recognition patterns enabled but only use a set of them. Also, recognition patterns that are enabled in the AEGM-P are used as an alternative input depending on the user's disabilities and device. This utilization process is done by the Multimodal Amalgamator, which works on the background of every game and handles the input of the user. Amalgamator searches through the AEGM-P, during game load, and enables the chosen patterns in order to make the user experience best per device.

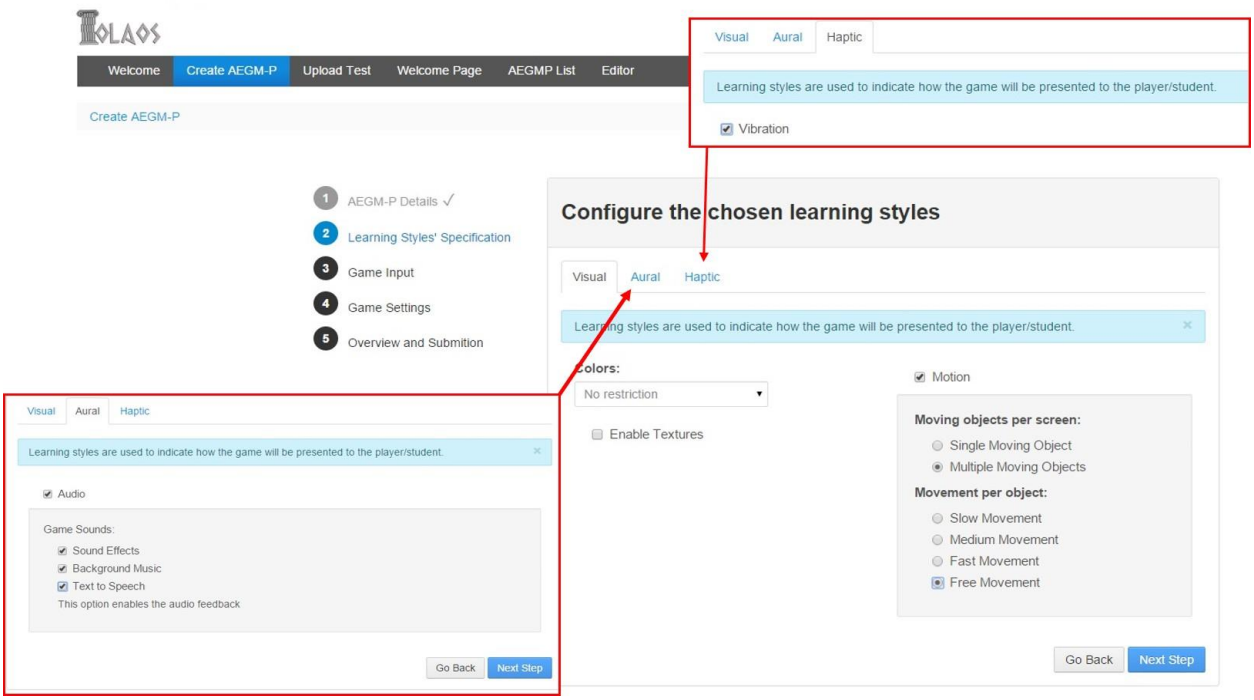


Figure 11 - AEGM-P Synthesis Step 2: Learning Styles Specifications

The last step of AEGM-P creation is Game Settings. Firstly, the expert must set the range of the permitted scenes per game, this variable has many different meanings for an educational game. An educational game can have either 1 single scene which is repeated or a number of scenes that form a continuing game that always presents new levels that challenge the player's current skills.

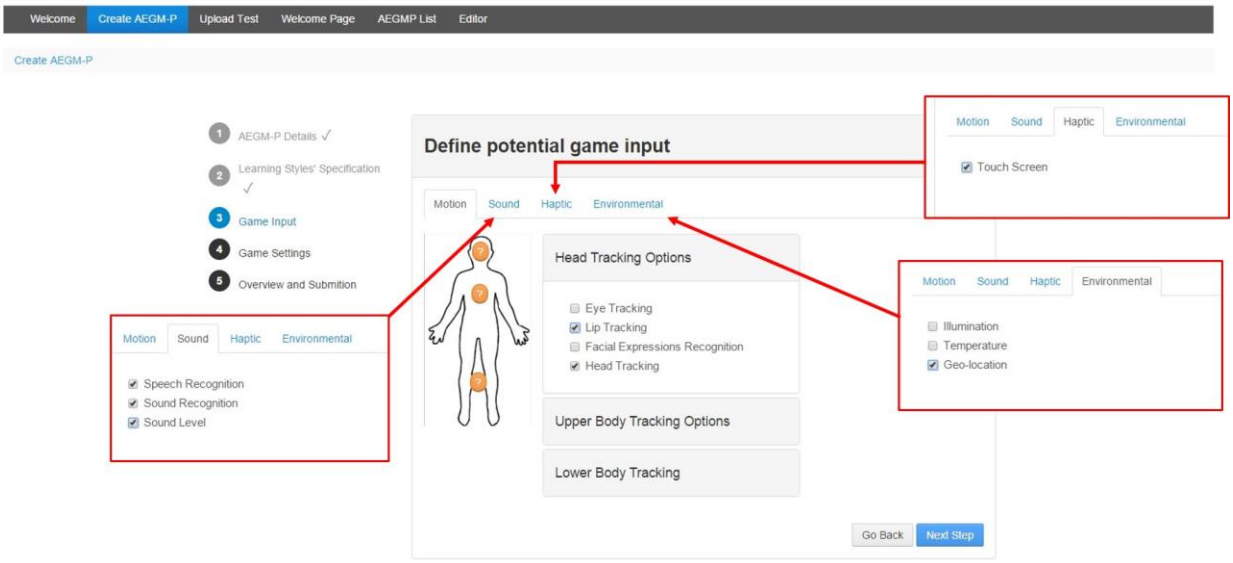


Figure 12 - AEGM-P Synthesis Step 3: Game Input

This depends on the educational theory that the expert wants to digitize and also to which group of students this AEGM-P refers to. For example, there cannot be many scenes in a game for children with ADHD because it will be difficult to keep the player's concentration for long and it will not be so efficient. The rest of this steps categories have been divided into for main subcategories (as stated in the description of IOLAOS' architecture), but not all of them have features in all subcategories. Evaluation is based on in-game events, namely, time to complete the game, time spent in-game, total tries to beat it and chat log to evaluate communication skills but also to be cautious of how the students approach the problem.

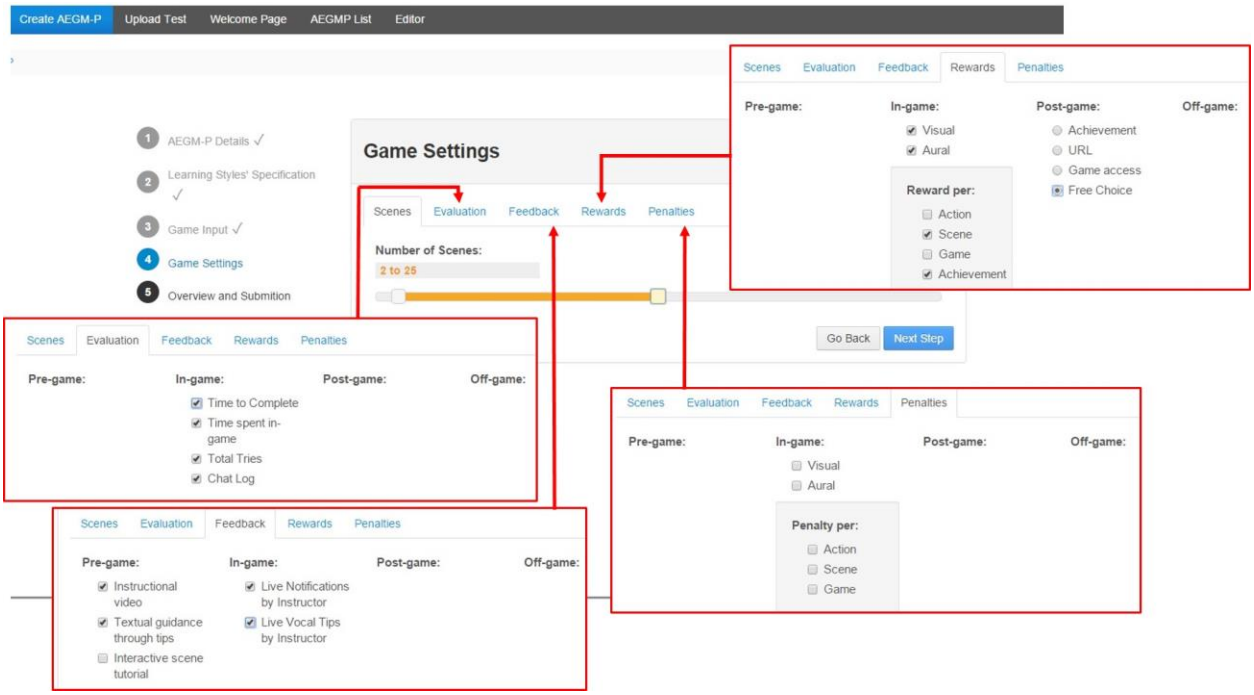


Figure 13 - AEGM-P Synthesis Step 4: Game Settings

Feedback has pre-game and in-game aspects such as Instructional videos, textual guidance and interactive scent tutorial to introduce the controls and game mechanics or the game background story to the player. But also, live textual notifications or live vocal tips by the instructor. It must be noted that in-game feedback using game assets such as sounds, visual output etc. is automatically set through learning styles' specification step. The output options that are set for the game are also used for the feedback assets. This rule applies also for rewards and

penalties as soon as the expert enables the “Visual” and/or “Aural” option on their respective panel.

When the AEGM-P is ready and the expert pressed save, the model is stored in IOLAOS’ database and can be seen in the list of available models to start game creation

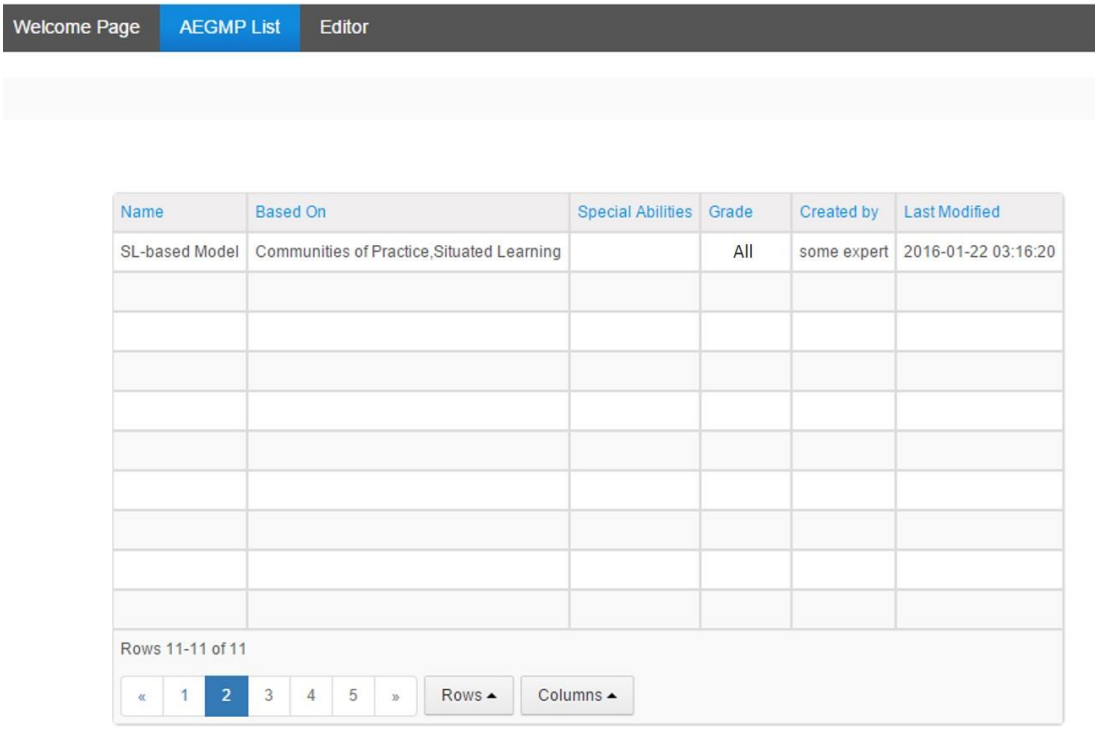


Figure 14 - AEGM-P List

Scenario 2

Exhibit 2: The game begins at paused and a dialogue at the bottom of the screen shows the main character talking to the player. Through this dialogue the main character passes information to the player concerning (a) the purpose and goal of the game, (b) interaction possibilities and (c) motion guidelines. Having being informed the player closes the instruction dialogue and the game begins. She/he can use any input modality that is available on her/his device and permitted by the game. In our reference scenario the permitted input modalities are "keyboard" and "microphone". An available modality bar with appropriate icons is displayed on the top right corner of the screen. When the player uses a modality its representing icon is highlighted by background color changes (green color means modality in use and red color means modality is idle). The player must cross the road only on the zebra crossings in order to reach the end destination, in our reference scenario the "Shop". If the main character crosses from anywhere else but the zebra crossings, then either there is a car present and the character collides with it or there is no car present. In both cases the game produces an appropriate text alert as feedback, for the wrong movement, to the main character and restarts. When the player gets to the final destination successfully, the game ends and the rewarding screen comes forth, informing the player on her/his achievement and the rewards gained.

Game compilation

According to our reference scenario the "Educator" creates the game by performing the following steps in IOLAOS platform: (a) Select appropriate template, (b) Customize template according to scenario requirements, (c) Generate game framework upon which, the "Educator", will construct/fabricate the game, by defining artifacts and behaviors. The outcome of the above process is an educational game for teaching schoolers road safety.

In more details, as presented in Fig. 26, initially the "Educator" selects "Game Create" and chooses the appropriate template provided, in our case the "Minimum body movement template". At step 2 "Template Parameterization", the "Educator" applies our representative scenario requirements which in our case are: a) the number of game scenes-levels are limited to 1 excluding welcome screen and final rewarding screen(s), b) the color scheme option is "Normal

Coloring", c) the Peripherals-Modalities for game navigation is performed via voice commands with the use of a microphone and keyboard strokes.

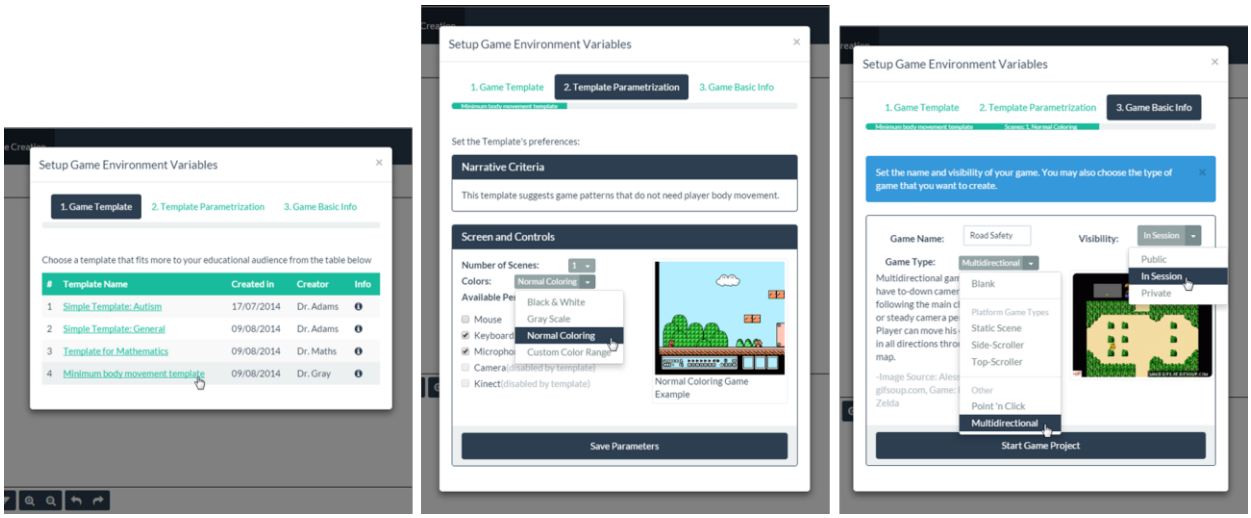


Figure 15 - Game Template Customization

At step 3 "Game Basic Info", the platform allows the "Educator" to provide game info such as "game name", "game visibility" and "game type" according to her/his desires and boundaries set up at step 2. In our reference scenario game name is "Road Safety", game visibility is "In Session" and game type is "Multidirectional".

After the customization of the selected template, the platform initiates the game editor and provides the assets and settings that the template suggests. The educator starts the game creation by dragging a dropping assets and scripts into the screen to create the scene and the game logic. In Figure 16 we can see the asset toolbox on the left of the screen. Assets are categorized into Buildings and Structures, Characters, Vehicles, Ground and Background. All of them are specifically for top view game because of the educator's choice (Top view) on template parametrization. When an asset is dropped on the scene, educator can click on it and see its details. Namely, details box on the right of the screen shows the name of the focused scene asset, its position on x and y axis, its width and height, the scale, the rotation and a list of scripts that the educator has dropped inside it. Position, Scale and Rotation of the focused asset can be edited by using the tools on the bottom of the scene.

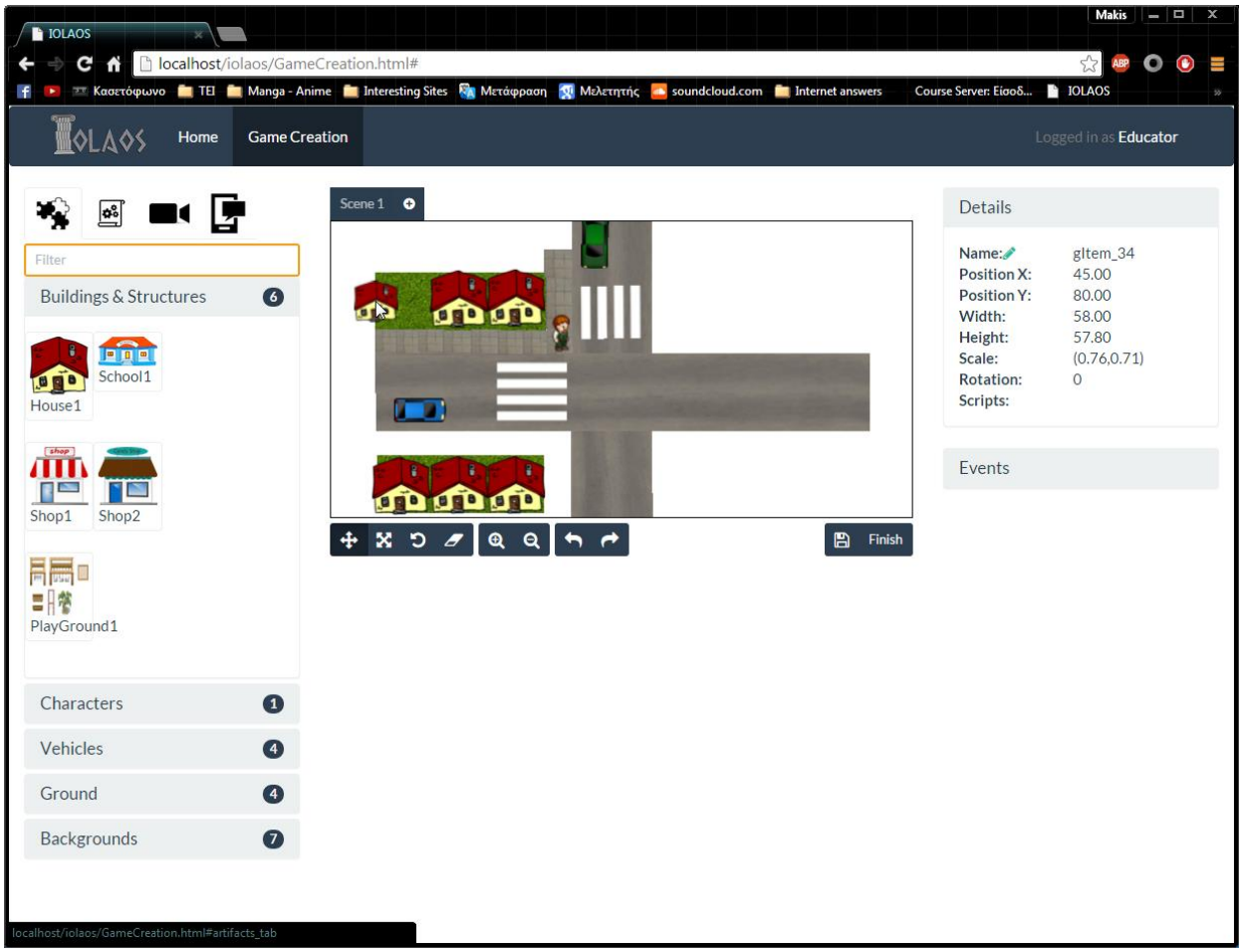


Figure 16 - Assets Toolbox in IOLAOS' Game editor

The second tab on the left toolbox of IOLAOS game editor is the scripts tap. Here the educator drags and drops scripts to a scene's asset details in order to assign them to it. There is also the option to remove a script from the asset by clicking the "x" button on the top left of each one. Also, some scripts have extra fields on their green box inside the asset details that define the required variables in order to be customized. For this scenario, the educator chooses "Movement Control" and "Collision Detection" scripts for the main character of the game. Movement Control will allow the player to use any allowed device to be used for controlling the main character's movement (in our case Keyboard and Microphone). Collision detection, as its title instructs, detects the collision between the main character and any other object that has collision properties. The scripts are going to be translated while the game engine will decode the saved game data that the creator/instructor will have assigned.

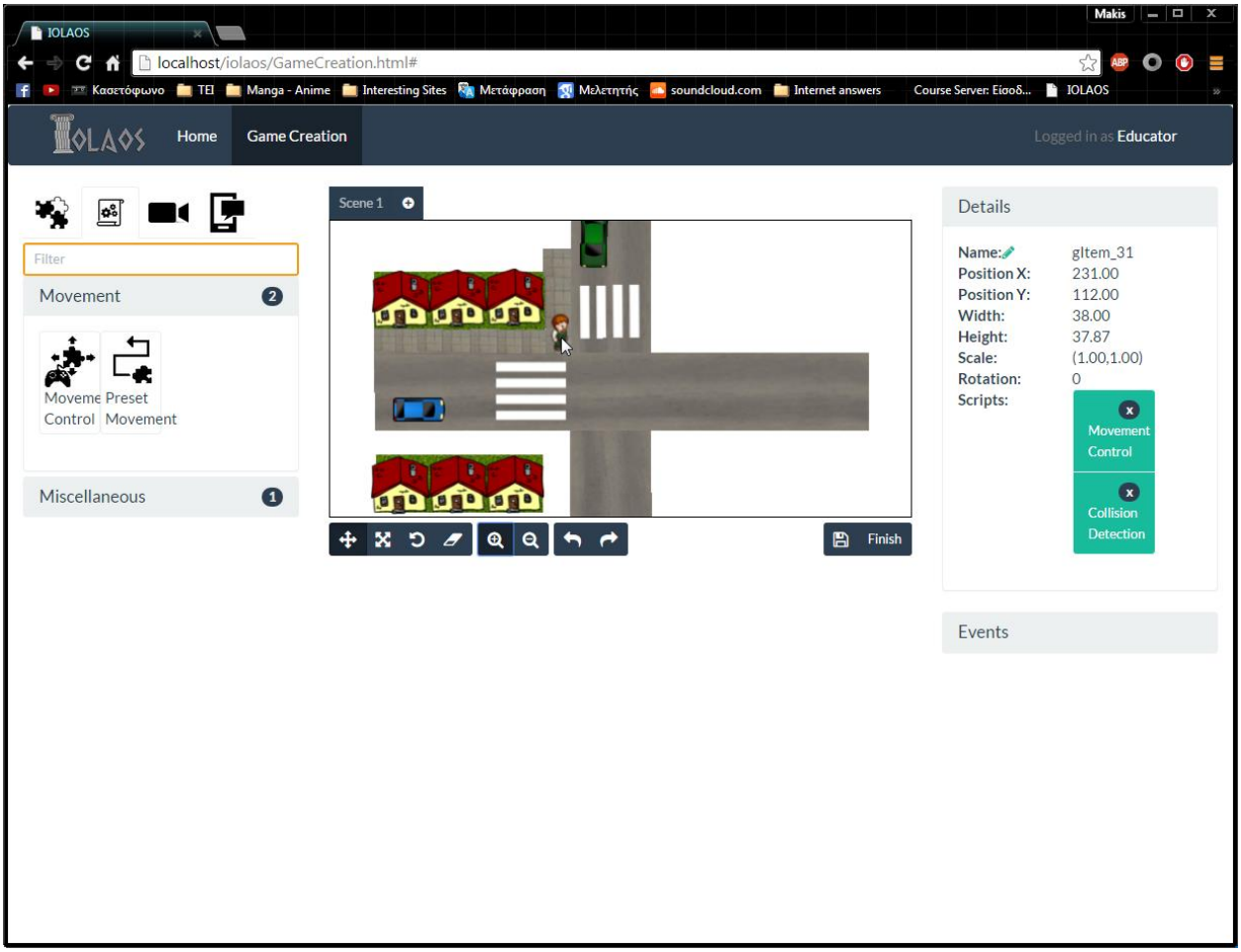


Figure 17 - Script Toolbox in IOLAOS' Game Editor

In this scenario, feedback is passed to player (a) through light coloring for the modality used (see top right corner of Figure 18) (b) through text alerts during game execution according to player moves and (c) as concluding feedback-rewarding at the end of the game. Feedback is initiated on certain events that are defined on its information when dragged and dropped into the scene. For example, the dialog that is shown in Figure 18 is initiated at the start of the scene and the next steps of the dialog are shown every time the player clicks the arrow on the bottom – right corner of the box or presses the keyboards down arrow. When the dialog text finishes the last dialogs arrow shuts down the dialog and disappears until the next start of this scene (from a failure of the objective or a regular scene restart initiated by the user. Feedback's are customizable but there are also ready to use sets that the creator can just drag and drop in the scene and be up and working with no particular setting (like Elapsed Time, the top-right "input menu" etc.).

Figure 18 – Setting up User Feedback

Moving to the creation of the Reward Scene, the Educator used a Background from the Assets Toolbox and as Figure 19 uses the Feedback tab of the left toolbox to create the desired scene as a reward to the player as well as the asset tab to use some assets known to the user, such as the main character, the instructor’s avatar, a police officer etc.

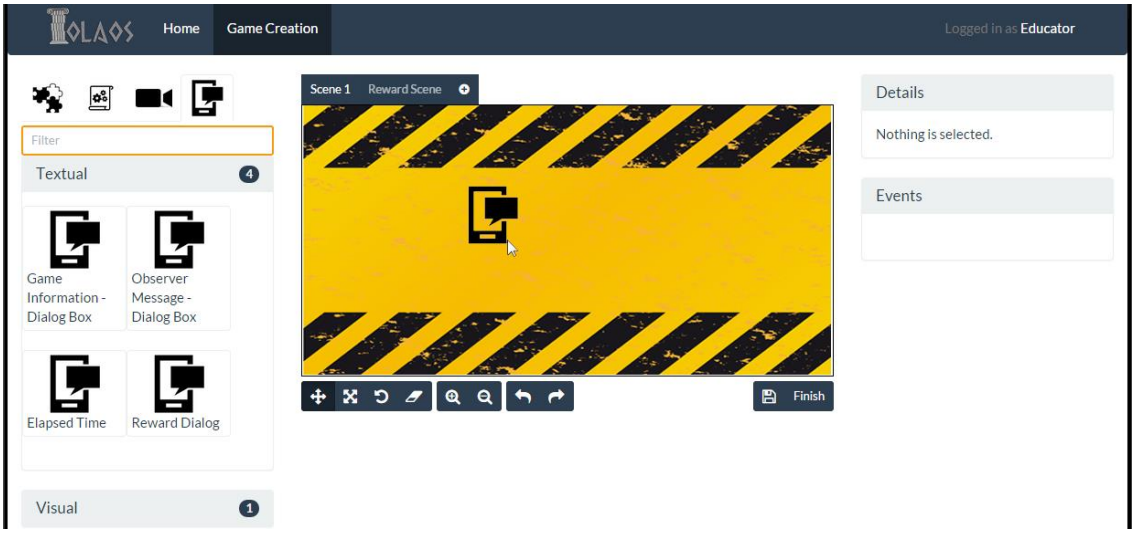


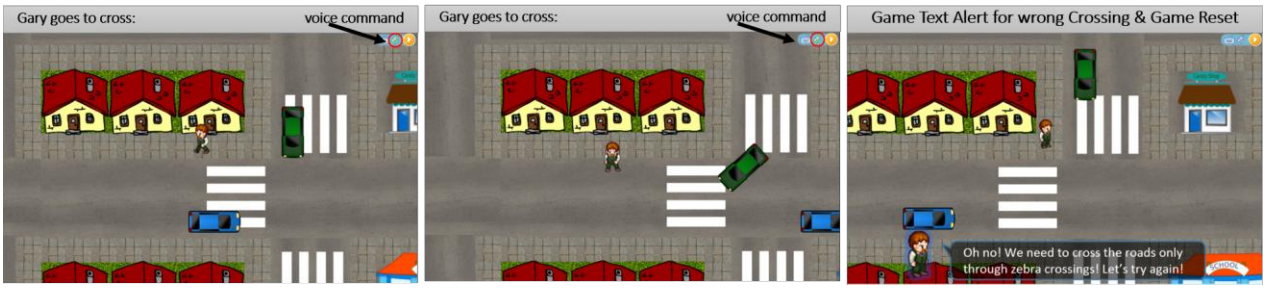
Figure 19 - Feedback Toolbox and Reward Scene of IOLAOS Game Editor

Play Game

The game begins paused and a dialogue at the bottom of the screen shows the main character "Gary" talking to the player. Through this dialogue the main character passes information to the player concerning (a) the purpose and goal of the game, (b) interaction possibilities and (c) motion guidelines (see Figure 18**Fig. 27**). When the child feels ready, she/he can choose to start the game.

To enlighten the different aspect of the game we describe three different playing scenarios namely the "Wrong Crossing" scenario (see Figure 20), the "Collision with Car" scenario (see Figure 21) and the "Successful Crossing" scenario (see Figure 22). The goal of the main character "Gary" is to go to a shop safely.

In more detail at the "Wrong Crossing" scenario the player navigates Gary", with the use of voice commands to cross the road from the wrong place outside the zebra crossing. The active modality (voice command) is highlighted at the top right corner of the scene where the microphone device icon is turned to light green color (see Figure 20 a, b). As a result of the wrong actions of "Gary" the game (a) provides the appropriate feedback, and (b) resets and urges "Gary" to use one of the zebra crossings (see Figure 20 c).



a b c

Figure 20 - Play Scenario: Wrong Crossing

At the "Collision with Car" scenario the player navigates "Gary", with the use of voice commands to cross the road from the zebra crossing but without checking if there is a vehicle passing. The active modality (voice command) is highlighted at the top right corner of the scene where the microphone device icon is turned to light green color (see Figure 21, left screenshots). As a result of the negligent action of "Gary" the game (a) ends and the player lose, and (b) resets and urges "Gary" to be more careful with passing cars (see right screenshot of Figure 21).

Figure 21 - Play Scenario: Collision with Car

Moving on with our play time scenarios, at the "Successful Crossing" scenario the player navigates "Gary", with a different modality from the other two scenarios namely keyboard strokes to cross the road from the zebra crossing after checking for passing vehicles. The active modality (keyboard strokes) is highlighted at the top right corner of the scene where the keyboard device icon is turned to light green color (see Figure 22, left screenshots). As a result of the correct road crossing attribute of "Gary" the game (a) ends successfully with "Gary" reaching his destination, and (b) informs "Gary" about his achievement (see right screenshot of Figure 22). The game concludes with the appropriate rewarding scene.

Figure 22 - Play Scenario: Successful Crossing

Chapter 5 - Conclusion

In this thesis we have attempted to sketch the organizational underpinnings of our platform, presenting a pilot effort that aims to build an open authorable framework for educational games for children. Our primary design target is to set up an operational model for carrying out the codification of learning styles, educational theories, pedagogical methods and evaluation models as well as the generation of ludic, narrative, and educational games according to needs, abilities and educational goals along with supporting his model with appropriate software platform and tools. Under this scope, we investigate the gaps between educational experts and game designers in order to find a communication basis for the two most valuable yet completely different aspects of educational games. By identifying educational models which already exist in the concept of games, we analyze and develop an operational model for carrying out the codification of learning styles and educational theories. Finally, we tested the system's sequential process of creating an educational game from scratch with the scenario of a simple road safety game.

The flexibility which AEGM-P provides, enables education experts to provide concrete information about the game based on their knowledge of educational theories and learning styles, as well as define specific information based on the game's target group to game creators in a form which is compliant to their domain. Furthermore, experts can specialize their models based on the target group's age, special abilities etc. Consequently, game creators are provided with domain-specific information thus the process of game creation is not restrained by communication issues. Finally, the created AEGM-P affords reusability by its architectural abstraction.

Future Work

Ongoing work covers a variety of issues of both technological and educational engineering character. Some of the issues to be addressed in the immediate future include:

(a) Elaborate on the Inclusive Educational Training Module, to widen its functionality and use more of its multiplatform capabilities in order to reach more audience with

less effort by the educator. Also, the training module can become more adaptive to the user's skill level and change the difficulty on runtime.

(b) Further exploration of learning styles, educational theories, pedagogical methods and evaluation models in collaboration with expert and educator professional associations so that our AEGM-P model can be customizable enough to describe any of the above.

(c) Run various use cases in vivo with the guidance and involvement of expert and educator professional associations in order to measure the effectiveness of the digitalized learning styles and educational theories and

(d) Enhance ludology aiming not only to children experience, but also to experts and teachers.

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Appendix

List of published papers

1) "**Ludic Educational Game Creation Tool: Teaching Schoolers Road Safety**"

Universal Access in Human-Computer Interaction. Access to Learning, Health and Well-Being, M. Antona and C Stephanidis, Eds Springer International Publishing, 2015, , pp. 565–576.

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3) "**Concealing Education Into Games**"

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Authors: N. Vidakis, **E. Syntychakis**, K. Kalafatis, P. Varhalamas, and G. Triantafyllidis

Ludic Educational Game Creation Tool: teaching schoolers road safety

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Abstract. This paper presents initial findings and ongoing work of the game creation tool, a core component of the IOLAOS[1] platform, a general open authorable framework for educational and training games. The game creation tool features a web editor, where the game narrative can be manipulated, according to specific needs. Moreover, this tool is applied for creating an educational game according to a reference scenario namely teaching schoolers road safety. A ludic approach is used both in game creation and play. Helping children staying safe and preventing serious injury on the roads is crucial. In this context, this work presents an augmented version of the IOLAOS architecture including an enhanced game creation tool and a new multimodality module. In addition presents a case study for creating educational games for teaching road safety, by employing ludic interfaces for both the game creator and the game player, as well as ludic game design.

Keywords: Educational Game · Road Safety · Open Authorable Framework · Ludic Game Design

1 Introduction

Educational games for children have been widely used in supporting learning inside and out of school and as a result a growing interest has appeared for the potential of digital games to deliver effective and engaging learning experiences [5]. There is a variety of computer games and software that intend to assist users to achieve various educational goals. Educational gaming is a great platform that helps in motivating students to learn and is designed to teach students about a specific subject and/or skills. Prensky in [3] argues that children are naturally motivated to play games. Educational games are interactions that teach students goals, rules, adaptation, problem solving, interaction, all represented as a narrative. Such games give them the funda-

[1] IOLAOS in ancient Greece was a divine hero famed for helping with some of Heracles's labors.

mental needs of learning by providing enjoyment, passionate involvement, structure, motivation, ego gratification, adrenaline, creativity, interaction and emotion. "*Play has a deep biological, evolutionarily, important function, which has to do specifically with learning*" [3].

In general, computer games and other digital technologies such as mobile phones and the Internet seem to stimulate playful goals and to facilitate the construction of playful identities. This transformation advances the ludification of today's culture in the spirit of Johan Huizinga's homo ludens [4]. In this context, this ludification of today's culture can be also used in educational activities to strengthen the motivation and the engagement of the students.

In this paper, we introduce the game creation tool of the IOLAOS platform [1, 2] which is an open authorable framework for educational games for children. IOLAOS aims to employ ludic elements to provide efficient educational gaming for children.

IOLAOS suggests a fully authorable editor, with which, educational experts can create templates and teachers can shape and customize the template-based games according to specific needs for a more personalized education. It's important that such customizations can be performed easily and without the reliance on software developers. The editor is also open. This means that new templates can be added easily for creating new games serving new educational goals.

Regarding the ludic approach, IOLAOS game creation tool features ludic elements for creating games, which support the use of natural user interface (NUI) for the playing. A NUI is a human-computer interface that allows humans to communicate with the computer using standard modes of human communication such as speech or gestures, and to manipulate virtual objects in a fashion similar to the way humans manipulate physical objects. During the last few years, technology has been improved rapidly and allowed the creation of efficient and low-cost applications featuring NUIs. One of the characteristics of a successful NUI is thus the reduction of cognitive load on people interacting with it. This is an important feature that makes NUI a suitable interface in developing successful learning applications. In our approach NUI focuses on the kinesthetic factor (gestures, movements, etc), which is an important element in achieving the required playfulness of a ludic interface. For example, it is much more "fun" in a game to drive a car with your hands naturally, compared to pressing some keyboard keys. And this is even more important and critical when the target group is children.

Besides the ludic interface, ludic design for the game has been also employed in the game creation tool in order to improve playfulness, make the educational games more attractive for the children and aim to improve the learning procedure.

As a proof of concept for the IOLAOS game creation tool, a work scenario is presented in this paper, for creating an education game for teaching schoolers about road safety.

The rest of the paper is organized as follows. In section 2, a brief presentation of similar existing work and the context of relevant educational games in road safety is presented. Section 3 focuses on the proposed architecture of the IOLAOS game creation tool. To illustrate the concepts of the proposed architecture, Section 4 presents the scenario for teaching schoolers road safety and how is this possible by using the

IOLAOS framework. Finally, Section 5 describes conclusions and discusses future work.

2 Background work in road safety education

The pedestrian accidents are considered as one of the most serious of all health risks facing children in developed countries with United Kingdom (U.K.) leading Europe in the rate of child pedestrian fatalities [6]. In United States (U.S.), the fifth leading cause of unintentional injury death to children aged 1-14 years is also the pedestrian injury [7]. In 2012, more than one in every five children between the ages of 5 and 15 who were killed in traffic crashes were pedestrians [8].

Young children are most susceptible to pedestrian injury as they are not capable of making decisions concerning their safety. The perception of road danger depends on cognitive development, which may impose limitations on the children's ability to make decisions when negotiate crossing traffic-filled roads. Crossing a street safely is a cognitively difficult task for them as it requires planning and multiple steps. The several functions required for safe pedestrian ability are developed through early and middle childhood [9].

For safe street-crossing, children must develop a wide range of abilities such as cognitive, perceptual and decision making skills. They must be able to choose the appropriate location to judge the traffic, to accurately perceive the speed and the distance of oncoming traffic and finally to determine the safest root to cross the road. Oxley et al. [10] conducted a research to evaluate the effectiveness of a targeted and practical training program for primary school children aged between 6 and 10 years using a simulated road environment. In this study, the children had to make road-crossing decisions in a simulated road environment in which time gap and speed of approaching vehicles were manipulated. Their results suggested that children predominantly made decisions based on distance gap and that younger children (6–7 year olds) were 12 times more likely than older children (8–10 year olds) to make critically incorrect (or unsafe) crossing decisions. Factors found to be associated with incorrect crossing decisions included lower perceptual, attentional, cognitive and executive performance, and independent travel.

Several scholars have previously considered ways to teach children relevant skills for pedestrian road safety. Different type of interventions have been proposed such as interactive classroom training, computer-based training, virtual reality training, film or video training and verbal instruction training. Many school-based training programs have been implemented in order to increase children's knowledge of road safety. These initially training programs revealed that there are many variables that can affect the judgments of children and have been considered broadly ineffective because they often do not include behavioral training techniques and rely on parents to implement practice outside of the classroom [11]. Classroom approaches are also criticized for focusing on increasing children's knowledge about road safety rather than providing practical skills to use in real situations in order to improve traffic behavior. Zeedyk et al. [12] conducted a classroom-based study that employed commercially

marketed products, a three-dimensional model of the traffic environment, a road safety board game and illustrated posters and flip-chart materials for teaching children about road safety. They showed that although classroom training succeed in increasing children's knowledge, children who received such training failed to automatically transfer these knowledge to behavior and performed no better in a real-traffic environment than children in their control group.

Alternative solutions have been used for children pedestrian safety through the use of virtual reality training. Bart et al. [13] examined street crossing behavior of children in real and virtual environments. In this study, typical developed children between 7 and 12 years old were trained to cross the street safely using a virtual reality environment. The results showed that the simulation employed in this study had a positive effect on children's street crossing behavior. This intervention was effective as the children improved not only their street crossing behavior in the virtual environment but could successfully transfer this improvement into the real street crossing environment. More recently, researchers suggested the development of virtual reality programs that might be disseminated broadly over the internet such as the internet-based virtual system that was proposed as an environment to train 7-8 year old children in pedestrian safety [14]. This program was developed using Unity 3D software and runs on any internet-connected computer and could also be adapted for mobile devices. The preliminary results indicated that this program offered a feasible environment for pedestrian training, it was educational and entertaining and children remained engaged and attentive while playing the game. Another study [15] examined the efficacy of widely available videotapes and websites used as training tools that require no or minimal adult support to implement in order to teach children safe pedestrian route selection skills. They compared these interventions to alternative pedestrian safety training strategies, including one-on-one training with an experienced adult pedestrian that was focused primarily on gap selection but also addressed route selection. In this study children 7-8 years old were trained in route selection and results suggested that children improved their pedestrian route selection somewhat over time. However, children trained with videos and websites did not learn route selection more quickly or better than children who received no training, or than children in either of their active comparison groups. Furthermore, computer-based interventions can offer repeated practice but fail to address other aspects of pedestrian safety. Thus, these methods may be more effective when supplemented with other learning modes that teach basic road safety rules. A recent systematic review and meta-analysis that evaluates behavioral interventions to teach children pedestrian safety where authors discuss the importance of using theories of child development to design interventions can be found in [16]. In this review authors propose further research with attention to child development and point the importance to provide interventions according to the global needs that can be disseminated broadly at low cost. As pedestrian safety represents a significant global health issue it is important to consider the need for innovation in measurement of children's pedestrian behaviors and how to focus intervention efforts internationally.

3 The IOLAOS Platform

The design of IOLAOS platform focuses on setting up the operational model for carrying out the codification of educational theories and learning styles, the generation of ludic, narrative, and educational games according to needs, abilities and educational goals and the evaluation of an inclusive educational session. This design exhibits several novel characteristics, which differentiate an IOLAOS-based game from other forms of educational computer games and platforms. Our approach is not only concerned with educational computer games, but instead, it seeks to provide a guided learning environment for both educators and children, that is story-telling and play-based by combining narrative and ludic for harnessing knowledge. Consequently, its primary focus is to enable educators and children with the use of ludology to perform learning tasks and provide an effective and engaging learning experience.

3.1 The Architecture

The proposed architecture has been designed in order to support a game platform that fulfils the requirements of customized narratives, ludic interfaces and ludic game designing. The system architecture consists of four distinct components that collaborate together to: (a) codify all different elements of educational theories and learning styles available and to create templates which are then offered to game developers, (b) compile games through a three step process, namely *template customization*, *game creation* and *utilization definition*, (c) manage inclusive learning session and play room attributes and (d) administer all necessary elements, modalities, users and their roles, game engine parameters etc. Peripheral to the system architecture are knowledge derived from educational theories, learning styles, evaluation models, pedagogical methods and classroom practices. The main components of our architecture are the "*Template Codifier*", the "*Game Compiler*", the "*Inclusive Education Training*", the "*Multimodality Amalgamator*" and the "*System Administration*" as shown in Fig. 1**Error! Reference source not found.**.

The "*System Administration*" component of the platform is responsible for managing system attributes, template parameters, game elements, artifacts and behaviors, session attributes, input / output modalities, and user accounts and roles.

The "*Template Codifier*" component is accountable for systemize/codify the various elements of the educational theories, evaluation models, pedagogical theories and learning styles. This is achieved by imprinting the theory's elements using a tabbed stepwise process by the expert.

The "*Inclusive Education Training*" component of the system is responsible for setting up the appropriate space for playing and evaluating games. It consists of the "Learning Session Compilation", the "Class-Play Room Compilation", the "Evaluation Compilation", the "Observation Center Compilation" and the "Play Area(s)".

More details about the "*System Administration*", the "*Template Codifier*" and the "*Inclusive Education Training*" components can be found in [1, 2].

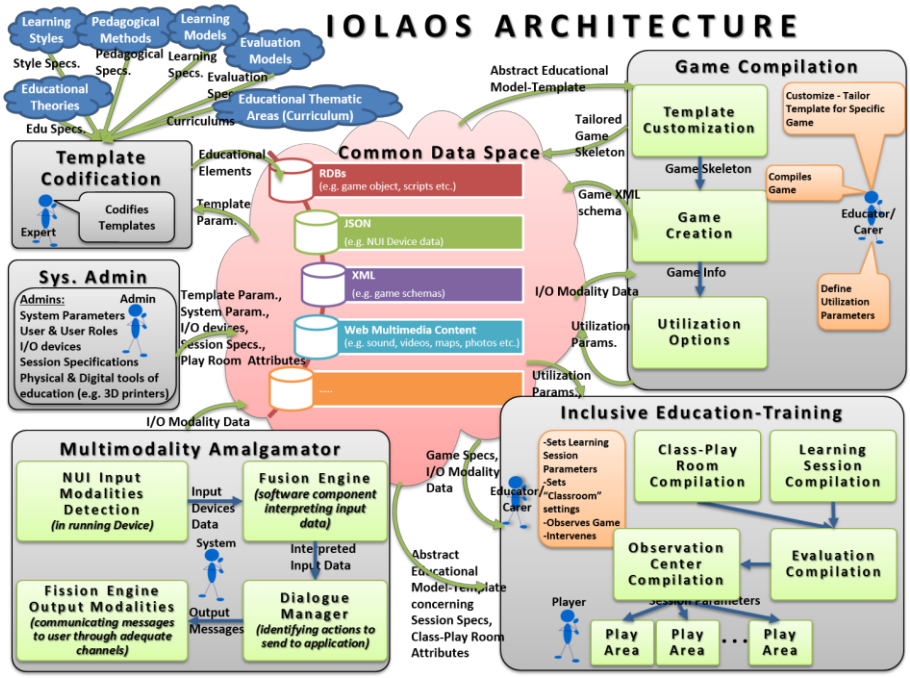


Fig. 1. System architecture

3.2 The Game Compiler Tool

The "Game Compiler" component (see and Fig. 2) of the system consists of the "Template Customization" the "Game Creation" and the "Utilization Management". It is responsible for providing the "Educator" with the necessary tools to set up a ludic educational game. In other words, it gives the "Educator" the possibility to (a) customize the generic template set up by the "Expert" at the "Template Codification" component in such a way that suits the specific game requirements according to target user group abilities and educational goals to be achieved, (b) create a ludic game with the use of the tools provided by IOLAOS platform (see Fig. 2) and (c) to define game utilization parameters such as: Free Use, Registered User Only, etc.

Fig. 2 exhibits selected elements of the game creation component based on our representative scenario described in section 4. In more details, the top left screenshot of the tool demonstrates the construction of the game from predefined and filtered game objects (see the left area from the game canvas) according to our representative scenario game template, namely the "Minimum body movement template". Furthermore, the placement of the game object is performed by drag and drop user actions using a mouse pointing device or a touch screen device. At the bottom of the game area there is a tool bar with appropriate tools for the manipulation of the game objects in respect to their attributes i.e. position, size, rotation, etc. The top right screenshot illustrates game object details in respect to object attributes and containing scripts. Finally the

bottom screenshot describes the rewarding scene(s) of the game and their content. A rewarding scene encompass game objects such as (a) textual, visual and sound feedback, (b) game artefacts and scripts and (c) evaluation object i.e. score, time etc. The rewarding scene canvas is activated by game creation completion according to the chosen educational game template.

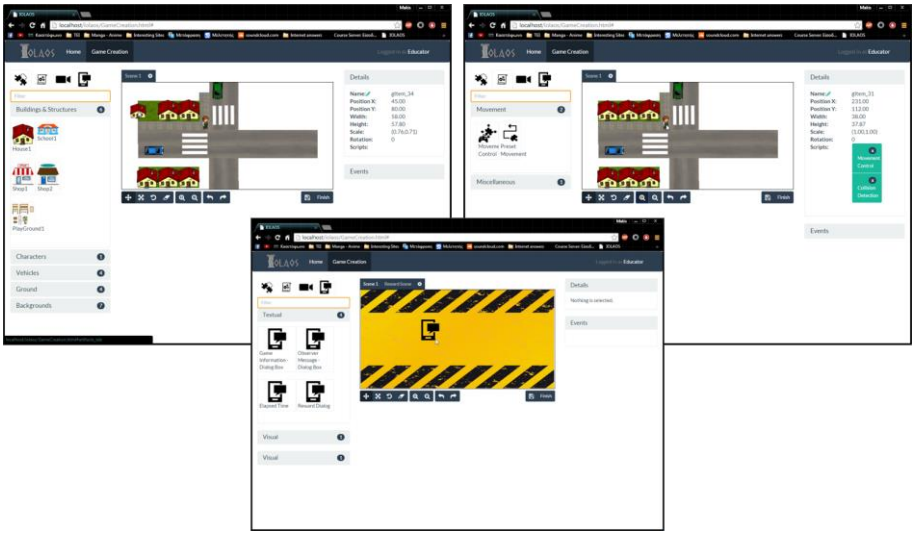


Fig. 2. IOLAOS Game Compiler component

Multimodal interaction systems aim to use naturally occurring forms of human communication as a way for human computer interaction [17]. In our system, the "Multimodality Amalgamator" component (see Fig. 1 and Fig. 3) uses modalities with very different characteristics such as speech, hand gestures and body movement, in addition with more commonplace input methods, in order to allow the user to have a more natural interaction with the application.

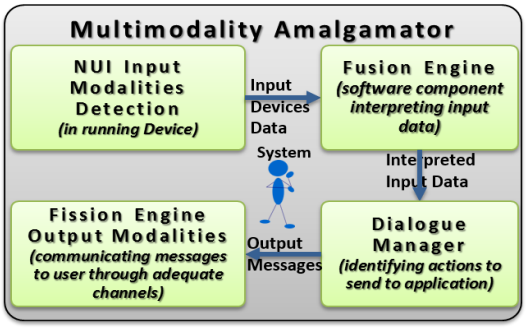


Fig. 3. Multimodal system component

The "NUI Input Modalities Detection" sub-component perceive input modalities through the appropriate input devices (e.g. microphone, web cam, etc.). Its results are

then passed to the "Fusion Engine" sub-component, a software component responsible for providing a common interpretation of the input data. The various levels of which the data can be fused is beyond the scope of this paper. When "Fusion Engine" reaches an interpretation, it is communicated to the "Dialogue Manager", in charge of identifying the action to communicate to the given application, and/or the message to return through the "Fission Engine Output Modalities" sub-component. The "Fission Engine Output Modalities" is finally in charge of returning a message to the user through the most adequate channel of communication (output modality), depending on the user profile.

4 Representative Scenario

To illustrate some of the concepts described so far and to provide insight into the Ludic Educational Game Creation Tool, we will briefly describe a representative scenario emphasizing on ludic, multimodal, narrative and authorable game creation for educating children. Our reference scenario is summarized in Exhibit 1.

Exhibit 1: The game begins at paused and a dialogue at the bottom of the screen shows the main character talking to the player. Through this dialogue the main character passes information to the player concerning (a) the purpose and goal of the game, (b) interaction possibilities and (c) motion guidelines. Having being informed the player closes the instruction dialogue and the game begins. She/he can use any input modality that is available on her/his device and permitted by the game. In our reference scenario the permitted input modalities are "keyboard" and "microphone". An available modality bar with appropriate icons is displayed on the top right corner of the screen. When the player uses a modality its representing icon is highlighted by background color changes (green color means modality in use and red color means modality is idle). The player must cross the road only on the zebra crossings in order to reach the end destination, in our reference scenario the "Shop". If the main character crosses from anywhere else but the zebra crossings then either there is a car present and the character collides with it or there is no car present. In both cases the game produces an appropriate text alert as feedback, for the wrong movement, to the main character and restarts. When the player gets to the final destination successfully, the game ends and the rewarding screen comes forth, informing the player on her/his achievement and the rewards gained.

4.1 Game compilation

According to our reference scenario the "Educator" creates the game by performing the following steps in IOLAOS platform: (a) Select appropriate template, (b) Customize template according to scenario requirements, (c) Generate game framework upon which, the "Educator", will construct/fabricate the game, by defining artifacts and behaviors. The outcome of the above process is an educational game for teaching schoolers road safety.

In more details, as presented in Fig. 4, initially the "Educator" selects "Game Create" and chooses the appropriate template provided, in our case the "Minimum body movement template". At step 2 "Template Parameterization", the "Educator" applies our representative scenario requirements which in our case are: a) the number of game scenes-levels are limited to 1 excluding welcome screen and final rewarding screen(s), b) the color scheme option is "Normal Coloring", c) the Peripherals-Modalities for game navigation is performed via voice commands with the use of a microphone and keyboard strokes.

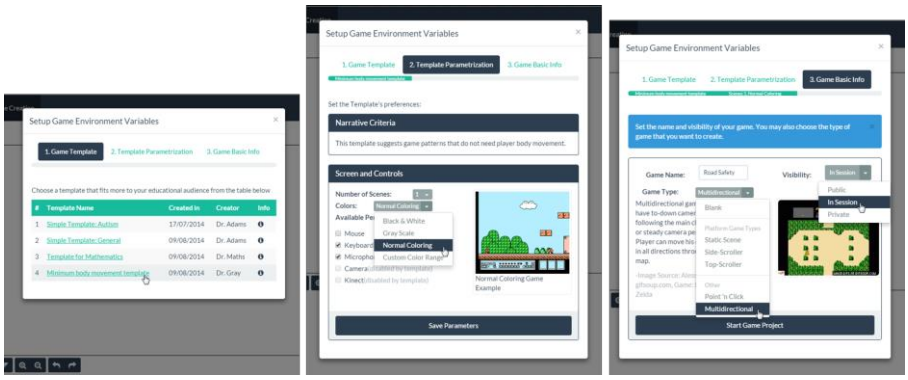


Fig. 4. Game Template Customization

Feedback is passed to player (a) through light coloring for the modality used (see top right corner of Fig. 5) (b) through text alerts during game execution according to player moves and (c) as concluding feedback-rewarding at the end of the game.

Fig. 5. Game Instruction Start Screen

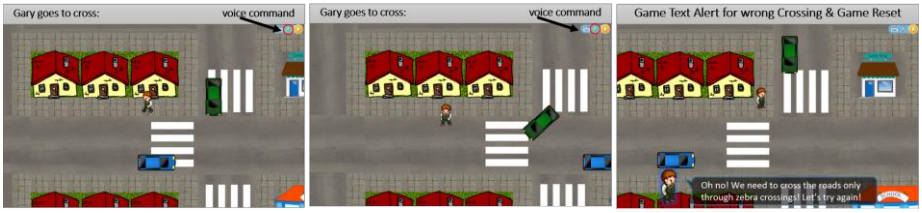
At step 3 "Game Basic Info", the platform allows the "Educator" to provide game info such as "game name", "game visibility" and "game type" according to her/his desires and boundaries set up at step 2. In our reference scenario game name is "Road Safety", game visibility is "In Session" and game type is "Multidirectional".

4.2 Play Game

The game begins paused and a dialogue at the bottom of the screen shows the main character "Gary" talking to the player. Through this dialogue the main character passes information to the player concerning (a) the purpose and goal of the game, (b) interaction possibilities and (c) motion guidelines (see Fig. 5). When the child feels ready, she/he can choose to start the game.

To enlighten the different aspect of the game we describe three different playing scenarios namely the "Wrong Crossing" scenario (see Fig. 6), the "Collision with Car" scenario (see Fig. 7) and the "Successful Crossing" scenario (see Fig. 8). The goal of the main character "Gary" is to go to a shop safely.

In more detail at the "Wrong Crossing" scenario the player navigates Gary", with the use of voice commands to cross the road from the wrong place outside the zebra crossing. The active modality (voice command) is highlighted at the top right corner of the scene where the microphone device icon is turned to light green color (see Fig. 6 a, b). As a result of the wrong actions of "Gary" the game (a) provides the appropriate feedback, and (b) resets and urges "Gary" to use one of the zebra crossings (see Fig. 6 c).



a b c

Fig. 6. Play Scenario: Wrong crossing

At the "Collision with Car" scenario the player navigates "Gary", with the use of voice commands to cross the road from the zebra crossing but without checking if there is a vehicle passing. The active modality (voice command) is highlighted at the top right corner of the scene where the microphone device icon is turned to light green color (see Fig. 7, left screenshots). As a result of the negligent action of "Gary" the game (a) ends and the player lose, and (b) resets and urges "Gary" to be more careful with passing cars (see right screenshot of Fig. 7).

Fig. 7. Play Scenario: Collision with Car

Moving on with our play time scenarios, at the "Successful Crossing" scenario the player navigates "Gary", with a different modality from the other two scenarios name-

ly keyboard strokes to cross the road from the zebra crossing after checking for passing vehicles. The active modality (keyboard strokes) is highlighted at the top right corner of the scene where the keyboard device icon is turned to light green color (see Fig. 8, left screenshots). As a result of the correct road crossing attribute of "Gary" the game (a) ends successfully with "Gary" reaching his destination, and (b) informs "Gary" about his achievement (see right screenshot of Fig. 8). The game concludes with the appropriate rewarding scene.

Fig. 8. Play Scenario: Successful crossing

5 Conclusion and Future Work

In this paper we have attempted to sketch the organizational underpinnings of the IOLAOS platform, a pilot effort aiming to build an open authorable framework for educational games for children by combining ludology and narratology. Our primary design target is to set up an operational model for carrying out the codification of learning styles, educational theories, pedagogical methods and evaluation models as well as the generation of ludic, narrative, and educational games according to needs, abilities and educational goals and to support this model with appropriate software platform and tools.

Ongoing work covers a variety of issues of both technological and educational engineering character. Some of the issues to be addressed in the immediate future include: (a) Elaborate on the Inclusive Educational-Training module, (b) Further exploration of learning styles, educational theories, pedagogical methods and evaluation models in collaboration with expert and educator professional associations, (c) Run various use cases in vivo with the guidance and involvement of expert and educator professional associations (d) Enhance ludology aiming not only to children experience, but also to experts and teachers, and (e) Elaborate further on the Multimodality Amalgamator module to involve more input and output modalities so that the roles between game player and machine are reversed and the player performs gestures, sounds, grimaces etc. and the machine responds.

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Designing a general open authorable digital ecosystem for educational games to support special learning needs

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Abstract. This chapter presents the design and the architecture of the IOLAOS[1] platform, a general open authorable ecosystem, aiming to increase the effectiveness of serious games for experts (researchers, specialists), carers (teachers, trainers, parents) and users (adults, schoolers, pre-schoolers) of socially, physically or technologically disadvantaged groups. In this context the main ambition of IOLAOS is to introduce the design and the tools for (a) enabling experts (theorists, physiologists, pedagogues, etc.) to codify therapy/recovery styles/limitations and pedagogical methods into game creation guidelines, (b) allowing carers (teachers, trainers, parents etc.) to create educational and/or rehabilitation games based on the experts codified guidelines, curriculum, and user specifics (c) permit users (adults, schooler, preschoolers etc.) to customize, to a certain point, the game according to their preferences and desires and play games alone or in groups with or without carer's supervision and (d) enable experts or carers to evaluate playing sessions and come to pedagogical and recovery conclusions / decisions. This platform will contribute to domains as diverse as health care and education. As a use case presented in this chapter, IOLAOS is applied for the scenario of teaching preschoolers with autism diagnosis. Children with autism have been reported to exhibit deficits in the recognition of affective expressions and the perception of emotions. In regard to this, the proposed approach with the suggested ecosystem creates a game to support interventions to eliminate such deficits.

1 Introduction

Increasingly, experts, teachers, parents and students look to technology as a complimentary support for their educations. Currently, ample researches have been done in Serious Games that cover matters related to education, therapy for communication, psychomotor treatment and social behavior enhancement. Michael Zyda [1] defines a Serious Game as: "a mental contest, played with a computer in accordance with specific

[1] IOLAOS in ancient Greece was a divine hero famed for helping with some of Heracles's labors.

adfa, p. 1, 2011.

rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives". Serious Games for education and health can be combined in a series of impairments such as autism or attention and concentration deficits.

Educational gaming is a great platform that helps in motivating students to learn and is designed to teach students about a specific subject and/or skills. Prensky in [2] argues that children are naturally motivated to play games. Educational games are interactions that teach students goals, rules, adaptation, problem solving, interaction, all represented as a narrative. Such games give them the fundamental needs of learning by providing enjoyment, passionate involvement, structure, motivation, ego gratification, adrenaline, creativity, interaction and emotion. "*Play has a deep biological, evolutionarily, important function, which has to do specifically with learning*" [2].

In general, computer games and other digital technologies such as mobile phones and the Internet seem to stimulate playful goals and to facilitate the construction of playful identities. This transformation advances the ludification of today's culture in the spirit of Johan Huizinga's homo ludens [3]. In this context, this ludification of today's culture can be also used in educational activities to strengthen the motivation and the engagement of the students as well as in rehabilitation to maintain patient motivation and interest.

Moreover, the narrative of an educational game plays an important role in its success. The story is the root of the whole gaming experience. Up to now, educational games are usually created with a closed architecture and a single narrative, resulting to fail in providing a more personalized or customized learning procedure.

In this chapter, we introduce the IOLAOS framework for Serious Games [4] that can be applied in a wide range of cases (from no conditions to severe) and ages (from toddlers to elderly people). IOLAOS aims to combine ludology and narratology improvements to provide efficient educational and therapy gaming for all.

Regarding the game narrative, IOLAOS suggests a fully authorable editor (implemented using the *Unity* game engine [5]), with which, experts can create templates and carers can shape and customize the template-based games according to specific needs for a more personalized education or rehabilitation. It's important that such customizations can be performed easily and without the reliance on software developers. The editor is also open. This means that new templates can be added easily for creating new games serving new educational or rehabilitation goals.

Regarding the ludic approach, IOLAOS features the use of natural user interface (NUI). NUI is a human-computer interface that allows humans to communicate with the computer using standard modes of human communication such as speech or gestures, and to manipulate virtual objects in a fashion similar to the way humans manipulate physical objects. During the last few years, technology has been improved rapidly and allowed the creation of efficient and low cost applications featuring these interfaces.

One of the characteristics of a successful NUI is thus the reduction of cognitive load on people interacting with it. This is an important feature that makes it a suitable interface in developing e.g. successful learning applications for children. In our design, NUI (instead of a restricted human-computer interface) is used to enhance playfulness and

thus establish a ludic interface. NUI features and focuses also on the kinesthetic factor (gestures, movements, etc), which is an important element in achieving this playfulness of a ludic interface. For example, it is much more "fun" in a game to drive a car with your hands naturally, compared to pressing some keyboard keys. And this is even more important and critical when the target group is children.

Besides the NUI-based interface, ludic design for the game has been also employed in order to improve playfulness, maintain patient motivation and interest, make the educational games more attractive for the children and aim to improve the learning and rehabilitation procedure.

Briefly, IOLAOS project:

- Introduces an open authorable narrative editor for creating templates and customizing educational and rehabilitation (healthcare) games, without the reliance on software developers.
- Employs a twofold ludic approach for both the interface (NUI) and the game design.
- Aims to a creation of more personalized games that support the educational and rehabilitation activities better.

As a proof of concept for the IOLAOS project, a work scenario is presented in this chapter, for creating an education game for teaching preschoolers with autism spectrum conditions (ASC) to improve their skills in recognizing facial expressions [6]. Facial expressions give important clues about emotions and provide a key mechanism for understanding, identifying and conveying them. Children with ASC often fail to recognize the qualitative differences and associations between various expressions of emotions [7]. Due to limited social and emotional understanding they do not know how to adequately interact with other people; a problem which sometimes leads to inappropriate behaviors. Studies have reported that individuals with ASC experience difficulties in recognizing expressions while in youth and experience problems recognizing emotions as adults [8].

Treatment approaches and rehabilitation aim to improve social interaction, conquest communication and control inappropriate behavior. Children with ASC are more likely to initiate positive interaction after treatment [9]. Education is also considered as a solution for the socio-emotional deficits and training is claimed to improve face processing abilities and strategies in autism [10]. A variety of educational interventions have been proposed for children with autism and many proponents have claimed developmental improvement and other benefits [11].

In this context, this chapter also presents how IOLAOS platform can be used in order to create an educational game featuring playfulness both in playing (NUI) and in designing the game, along with a customized narrative of the game, which can be edited according to the needs. Our aim is twofold, (a) to teach facial emotion recognition to preschoolers with ASC, and (b) to enhance their social interaction.

The rest of the chapter is organized as follows. In section 2, a brief presentation of similar existing work in creating educational games is presented. Section 3 focuses on the proposed open architecture of the IOLAOS project. To illustrate the concepts of the proposed architecture, Section 4 presents the scenario for teaching preschoolers with

ASC about expression recognition and how is this possible by using the IOLAOS framework. Finally, Section 5 describes conclusions and discusses future work.

2 Background

Educational games for children have been widely used in supporting learning in-side and out of school and as a result a growing interest has appeared for the potential of digital games to deliver effective and engaging learning experiences [12]. There is a variety of computer games and software that intend to assist users to achieve various educational goals. Well-known educational software is the project Scratch from MIT Media Lab [13], a programming language for learning to code. With Scratch users can program their own interactive stories, games and animations by putting together images, music and sounds with programming command blocks. Monterrat et al [14] in their study claimed that game moding as an educational activity could be interesting not only to learn programming but for any kind of learning. Their pedagogical tool allows people without game design skills to modify and share digital games. It allows a learner to become a teacher by designing an educational game that others can use to learn. Their main idea is that if learning a game helps students to acquire knowledge, then being able to change the game can provide students with the ability to deeply learn the content.

Narrative architecture and ludic design are two major approaches in contemporary video game theory. They both play important roles in teaching and learning as parts of educational gaming. Lester et al. [15] described the design issues and the empirical findings about motivation in narrative-centered learning environments. They found a strong connection between narrative and educational games and they claimed that narrative-centered learning environment is a promising approach for fostering positive learning gains, as well for promoting student motivation. On the other hand, Padilla-Zea et al. [16] included digital storytelling in an educational video game and introduced narrative elements to foster the students' motivation in learning processes by integrating specific educational models and ludic aspects. They claimed that ludic tasks in educational games are important elements to maintain students' interest, motivation and immersion.

During the last decade, researchers have begun to explore the use of computer technologies dedicated to ASC as intervention tools for improving and eliminating different deficits. In a recent review, Wainer and Ingersoll [17] examined innovation computer programs as educational interventions for people with ASC. They focused on studies describing programs to teach language, emotions or social skills. Their analysis showed that those tools are promising strategies for delivering direct intervention to individuals with ASC. Bernardini et al. [18] proposed a Serious Game for children with ASC to practice social communication skills; they used an intelligent virtual character that acts both as a peer and as a tutor on a number of different learning activities. These activities can be selected manually by a human operator (practitioner, parent or other carer) through a graphical interface. Their experimental results showed encouraging tendencies by relating the effectiveness of the children's interaction with the virtual character

acting as a social partner to them. Porayska-Pomsta et al. [19] suggest an intelligent and authorable environment to assist children with ASC in gaining social interaction skills. Their tool contains an intelligent agent and a play environment that allows teachers and parents to become co-creators and tailor the game according to the needs of the individual children in their care. Although the design and creation of personalized games is crucial for children with ASC, as reported by the authors, limitations in the agent's intelligence (agent inability to deal with inappropriate or unexpected behavior from the user) contradicts the structured, stable and predictable learning environment that is also crucial. The importance of active family participation in interventions and their collaboration in the research process have also been examined. Wright et al. [20] conducted a qualitative study to consider a tool to facilitate intergenerational family relationships. Their study examined social engagement among families with a child with ASC and the vital importance of the families in technology-based programs that promote social engagement and self-esteem for children with high functioning autism. Their findings support technology as a tool to facilitate family and social engagement in children with ASC. Current studies have also gone considerably beyond the simple use of computers. Diverse technology-based interventions have been employed for empowerment and skill acquisition. Recent reviews [21], [22] have shown that there is a growing number of interventions and report a variety of technologies such as interactive DVDs and virtual reality programs [23].

Ludology and narratology can also be considered as two important elements when creating educational games for children with ASC. Game narrative can provide context that assists children to apply the skills learned within the game. Ludology in both the interface and the game design also can engage children with autism in playful interactions and strengthen their motivation. Foster et al. [24] have suggested embedding interactive narrative in multimodal learning environments for social skill improvement of children with ASC. Castelhano et al. [25] studied therapeutic activities for children with developmental disabilities with the use of multisensory stimulation environments and documented its perception concerning ludic content, play and the computer-mediated ludic activity. The main theme that emerged from their study regarding playfulness was that the computer-mediated ludic experience is perceived as useful for intervention.

In general, educational computer games for children that combine ludology and narratology can provide an effective and engaging learning experience. Hence, developing learning environments that are both story-telling and play-based by combining narrative and ludicity may empower children to achieve great impact, improve deficits and gain new skills.

3 The IOLAOS Platform

The initial design of IOLAOS platform focuses on setting up the operational model for carrying out the codification of educational theories and learning styles as well as the generation of ludic, narrative, and educational games according to needs, abilities and educational goals. This design exhibits several novel characteristics, which differentiate an IOLAOS-based game from other forms of educational computer games and

platforms. First of all, IOLAOS is not only concerned with educational computer games, but instead, it seeks to provide a guided learning environment for both educators and children, that is story-telling and play-based by combining narrative and ludic for harnessing knowledge. Consequently, its primary focus is to enable educators and children with the use of ludology and naratology to perform learning tasks and provide an effective and engaging learning experience. To achieve this, IOLAOS builds on a range of technologies, including semantic web, game engines and advanced human-computer interaction. Secondly, IOLAOS adopts a knowledge-based, reuse-oriented and natural user interaction model to attain high quality during the performance of learning tasks.

3.1 The Architecture

The proposed architecture has been designed in order to support a game platform that fulfills the requirements of customized narratives, ludic interfaces and ludic game designing. The narrative is created by the expert and edited by the teacher according to learning needs and goals by using the template codification and template customization modules of the suggested architecture. The ludology is supported in two ways, first by creating and customizing ludic-based designed games through the template codification and game compilation components, and also by employing natural user interfaces to the playing process that enhance the playfulness of the game.

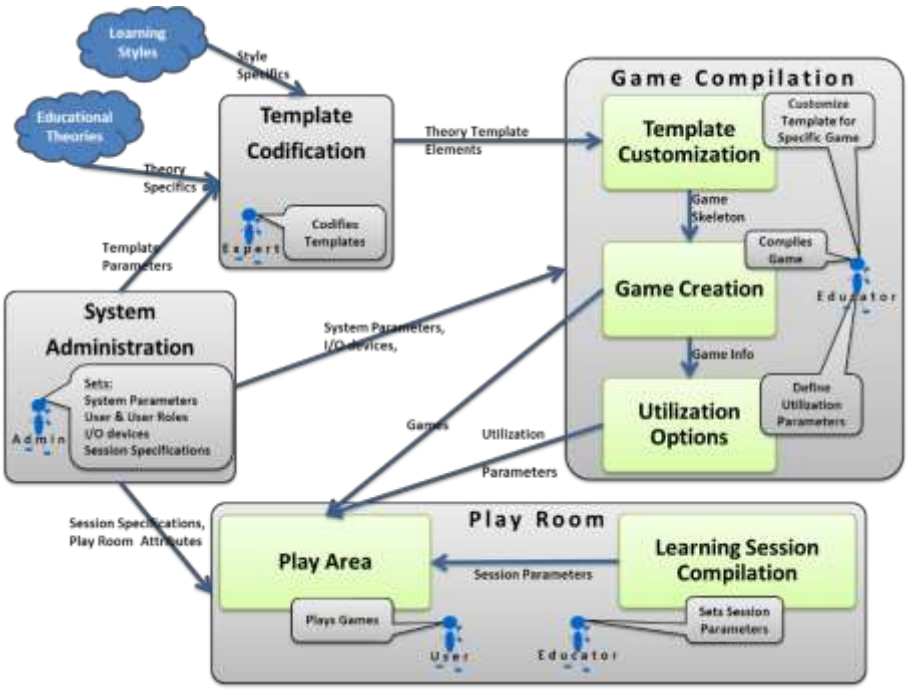

Fig. 1. System architecture

The system architecture (**Fig. 1**) consists of four distinct components that collaborate together to: (a) codify all different elements of educational theories and learning styles available and to create templates which are then offered to game developers, (b) compile games through a three step process, namely *template customization*, *game creation* and *utilization definition*, (c) manage learning session and play room attributes and (d) administer all necessary elements, users and their roles, game engine parameters etc. Peripheral to the system architecture are knowledge derived from educational theories, learning styles and classroom practices. The components of our architecture are the "*Template Codifier*", the "*Game Compiler*", the "*Play Room*" and the "*System Administration*". The following paragraphs describe in more details the above mentioned architectural components.

3.1.1 System Administration Component.

The "*System Administration*" component (see **Fig. 1**, **Fig. 2**) of the system is responsible for managing system attributes, template parameters, game elements, artifacts and behaviors, session attributes, input / output modalities, and user accounts and roles.

Fig. 2. IOLAOS administrator main screens

3.1.2 The Template Codification Component

The "*Template Codifier*" component (see **Fig. 1**, **Fig. 3**) of the system is accountable for systemize / codify the various elements of the educational theories and learning styles. This is achieved by imprinting the theory's elements using a tabbed stepwise process by the expert. Apart from the first steps, that imprint basic information about the theories, the process has no strict order of step execution. The template codification process that has been developed in IOLAOS in different tabs (see **Fig. 3**) gives the user

the capability to define the theory elements in an organized and clear manner. The educational theories and learning styles imprinting is performed by the role "Expert". The different groups of data that have been developed in IOLAOS for imprinting the theory's elements are: 'Template Basic Info', 'Style Basic Info', 'Target Group', 'Scenery Basics', 'Audio / Motion', 'Play Environment', 'Rewarding', 'Feedback' and 'Evaluation' (see **Fig. 3**).

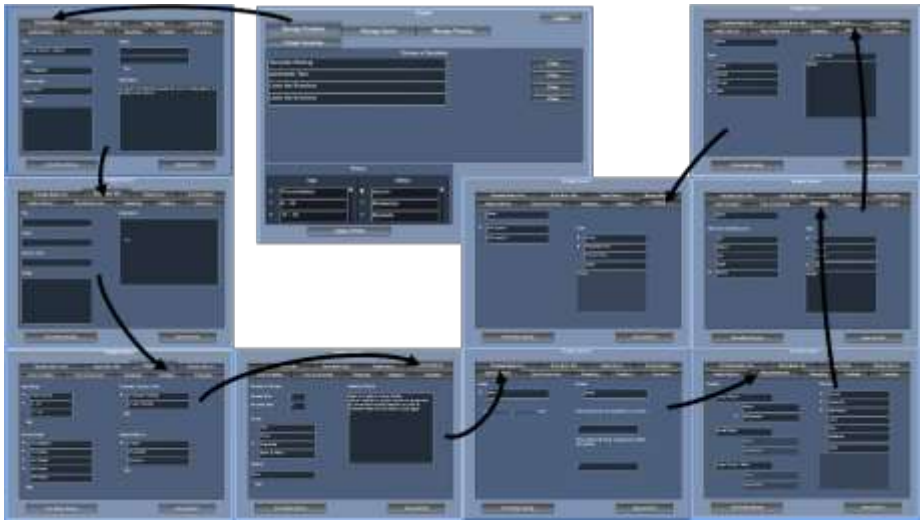

Fig. 3. The IOLAOS template codification and customization

In more detail, the theory's imprinting elements elucidate in:

- "*Template Basic Info*" records general data such as: Title, Description, Theory based upon, Template Author, Creation Date etc.,
- "*Style Basic Info*" records data concerning the learning style such as: Title, Description, Theory base upon, Template Author, Creation Date etc.,
- "*Target Group*" records data concerning player details, Abilities, and thematic areas such as: Age Group, School Grades, Thematic / Subject Area, Special Abilities etc.,
- "*Scenery Basics*" deals with data concerning the story telling that is involved in the game. Such data includes: Number of Scenes, Color Information, Texture, Motion, Narrative Criteria etc.,
- The "*Audio/Motion*" records data concerning the use of sound and image input/output modalities such as Audio (yes, no, scalable), Motion (yes, no, number and frequency of moving artifacts) etc.,
- "*Play_Environment*" documents data with reference to the type of game (i.e. single player, small group, etc.), the environment played (i.e. supervised or not supervised) and the peripherals used (i.e. classic I/O devises, NUI devices, etc).

- "*Rewarding*" deals with data concerning the rewarding of the player such as type of rewarding (i.e. textual, sound, movie, puzzle, etc.).
- "*Feedback*" records all necessary information about feedback before, during and after the game flow (i.e. text, sound, movie, score, etc.). and finally
- "*Evaluation*" deals with data concerning the evaluation of the player (i.e. evaluate per level or per game, or per game section etc.) as well as the evaluation type.

3.1.3 The Game Compilation Component

The "*Game Compiler*" component (see **Fig. 1**) of the system consists of the "*Template Customization*" the "*Game Creation*" and the "*Utilization Options*". It is responsible for providing the "Educator" with the necessary tools to set up a ludic educational game. In other words, it gives the "Educator" the possibility to (a) customize the generic template set up by the "Expert" at the "*Template Codification*" component in such a way that suits the specific game requirements (see **Fig. 3**) needed according to target user group abilities and goals to be achieved, (b) create a ludic game with the use of the tools provided by the IOLAOS platform (c) to define game utilization parameters such as: Free Use, Registered User Only, etc.

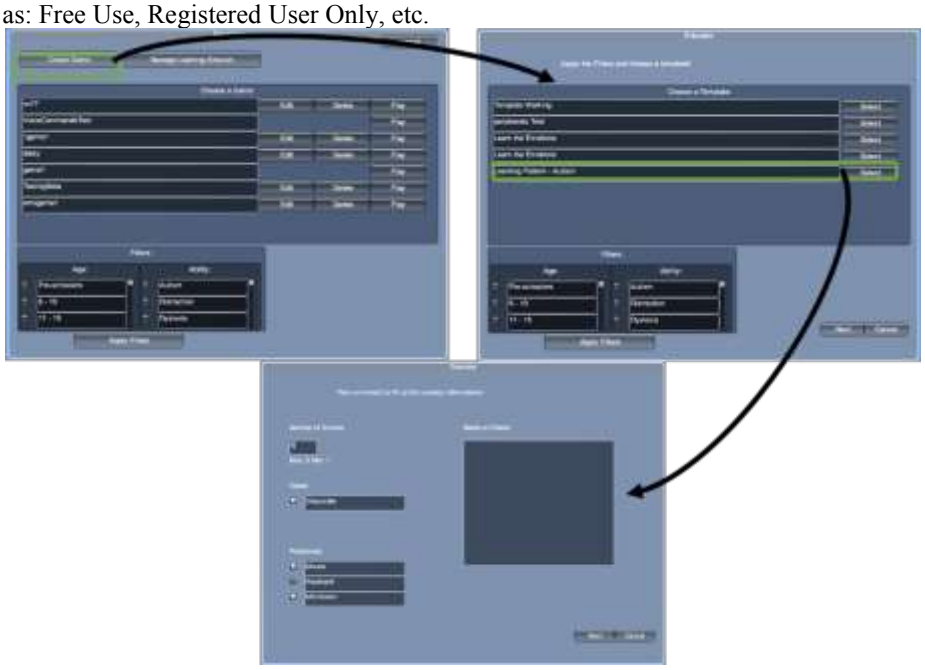

Fig. 4. The IOLAOS Template Customization

In more detail, at the 'Template Customization' step of the 'Game Compilation' component of the architecture the user chooses a predefined abstract educational template that suits its game criteria and proceeds to tailor this abstract template to the specific necessities of its current game. **Fig. 4** shows the IOLAOS platform elements that

enable the user to tailor the abstract educational template discussed above. Elaborating at the first screen of **Fig. 4** the user chooses game creation which triggers a serious of actions before the actual game construction (see **Fig. 5**). Initially the user chooses the predefined abstract educational template (see right up screen of **Fig. 4**), and then tailors the template (see bottom screen of **Fig. 4**) to suit the specifics of its game within the educational boundaries that the chosen abstract template stipulates.

Once the abstract template has been customized the user proceeds to construct the actual game with the use of the game creation editor provided by the IOLAOS platform. The game editor provides the user with a number of tool sets that allow a ludic, step wise, effortless, straightforward and uncomplicated game creation. These tool sets assemblage includes (a) a game object tank with predefined game objects, scripts, and backgrounds as well as facilities for custom object creation, (b) game scene management facility with scene navigation, addition and deletion, (c) game canvas management with gridding, sizing, locating options etc. and (d) game construction previewing facilities (see left screen of **Fig. 5**)

Fig. 5. The IOLAOS Game Creation

Upon completion of the game construction the user proceeds at the final step of the 'Game Compilation' component, namely the 'Utilization Options' (see **Fig. 6**). At this step utilization options such as game visibility (public or private), target game players, etc. are defined.

3.1.4 The Play Room Component

The "*Play Room*" component (see **Fig. 1**) is responsible for setting up the appropriate space for playing games and consists of "Learning Session Compilation" and "Play Area".

The "*Learning Session Compilation*" provides "Educator" the ability to fully manage learning sessions according to individual, group or class requirements every time she/he needs to run an educational game. In specific "Educator" can determine, (a) Players and/or Group, (b) Marking / Evaluation Specifics / Procedure, (c) Session Statistics, and (d) Session parameters. She/he can also save incomplete learning sessions in order to be completed in the future.

The "*Play Area*" deals with game runtime specifics such as save, load, single player or multi player parameters etc.

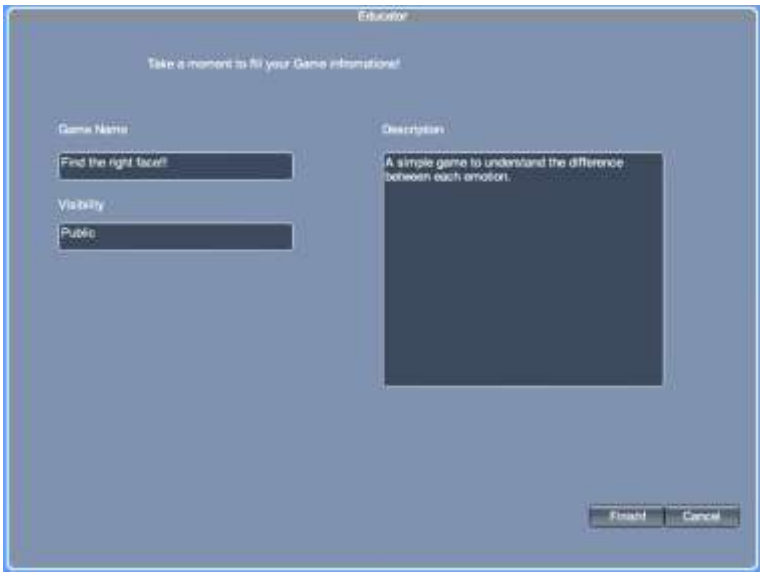

Fig. 6. The IOLAOS Utilization Options

4 Representative Scenario

Individuals with autism are usually visual learners, which mean that they understand written words, photos and visual information better than spoken language. Information is good to be presented through their strongest processing area. When teaching individuals with autism about emotions, it is important to keep explanations as simple and as concrete as possible. It is also recommended to describe each feeling pictorially by using pictures with clear outline, minimal details and color [26]. For young children it is advisable to keep to the basic emotions. In our approach, the basic emotions selected include happy, sad, angry, scared and surprised. Those emotions were chosen because typically developing children can recognize and understand them between 2 and 7 years of age. The face stimuli we used are grayscale photographs of male and female faces, taken from the CAlifornia Facial Expressions (CAFE) dataset [**Error! Reference source not found.**]. This dataset was selected as the most appropriate with respect to the emotion recognition task since all images meet FACS criteria [28] and all faces have been certified as "FACS-correct" [29]. The stimuli are presented on each trial with different pairs of photos and the goal is to choose the correct image.

To illustrate some of the concepts described so far and to provide insight into the features of IOLAOS platform, we will briefly describe a representative scenario emphasizing on ludic, narrative and authorable game creation for educating children with autism diagnosis. Our reference scenario is summarized in Exhibit 1. For more details see [30].

Exhibit 1: Game begins with an instruction page where the child is informed what is going to happen, what she/he has to do and how she/he can do it. A two-hand gesture

which is performed by moving both hands above the head is required to start the game. In the first level, children should learn labeling emotions by correlating emotion terms with images. The stimuli are presented on each trial with different pair of photos and the goal is to choose the correct image among the two. Selecting the left image (the orientation of the image is decided by looking toward the screen) requires a one-hand gesture which is performed by moving the left hand above the head. Selecting the right image (the orientation again of the image is decided by looking toward the screen) requires a one-hand gesture which is performed by moving the right hand above the head. Upon correct answer the '√' symbol appears on top of the image while upon incorrect answer, the 'x' symbol appears on top of the image. Moving to the next play area requires a two-hand gesture which is performed by moving both hands above the head. In the second level they should learn to recognize emotions from their description and their association with facial features. In the third level they should learn to identify the causes of various feelings in different situations, obtained through the use of social stories. At the end of the game, there is a congratulation message.

4.1 Game compilation

According to our reference scenario the "Educator" creates the game by performing the following steps in IOLAOS platform: (a) Select appropriate template, (b) Customize template according to scenario requirements, (c) Generate game framework upon which, the "Educator", will construct/fabricate the game, by defining artifacts and behaviors. The outcome of the above process is an educational game for children with autism diagnosis for recognizing emotions.

In more detail, the "Educator" selects "Create Game" and at **step1** ("Select appropriate template") she/he selects the appropriate template provided by IOLAOS, in our case the "Learning Pattern - Autism" (see **Fig. 7**).

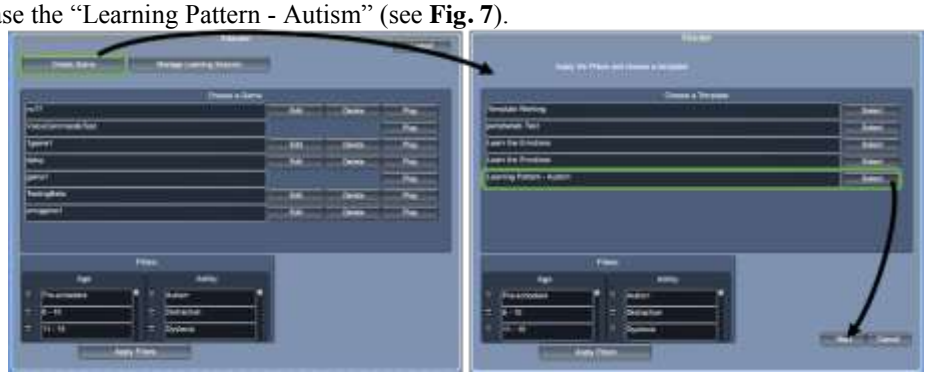

Fig. 7. Educator create game **step1:** "Select appropriate template"

At **step2** ("Customize template according to scenario requirements") the "Educator" applies the scenario requirements which in our case (see **Fig. 8**) are: 1) number of game levels are limited to 3 excluding welcome screen and final screen thus total 5 scenes, 2) feedback is passed to player through symbols for his/her choices (the '√' symbol for

correct answer and the ‘x’ symbol for wrong answer) during game execution and as concluding feedback at the end with the form of a congratulation message, and 3) game navigation is performed either by hand gestures with the use of MS-Kinect NUI device (raise left hand, right hand or both hands) or the mouse pointing device.

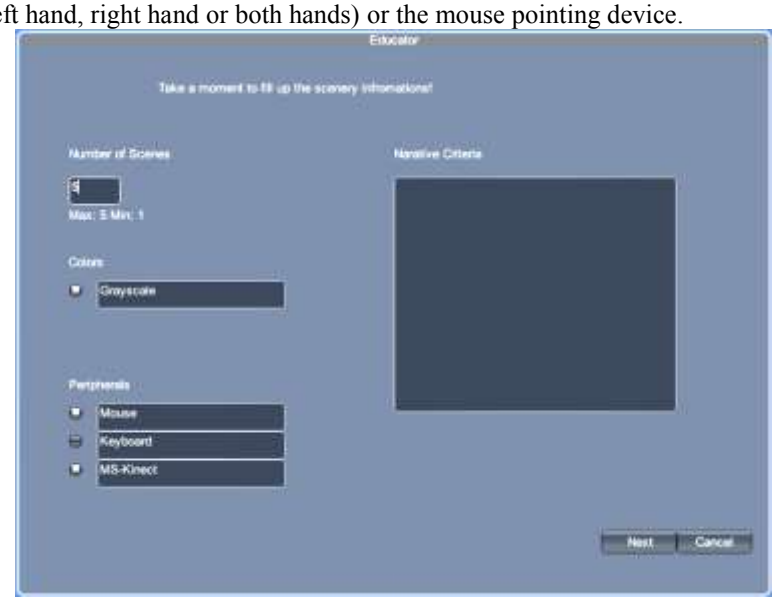

Fig. 8. Educator create game **step2:** “Customize template”

At **step 3** (“Generate Game Framework”) the platform allows the “Educator” to construct the game (see

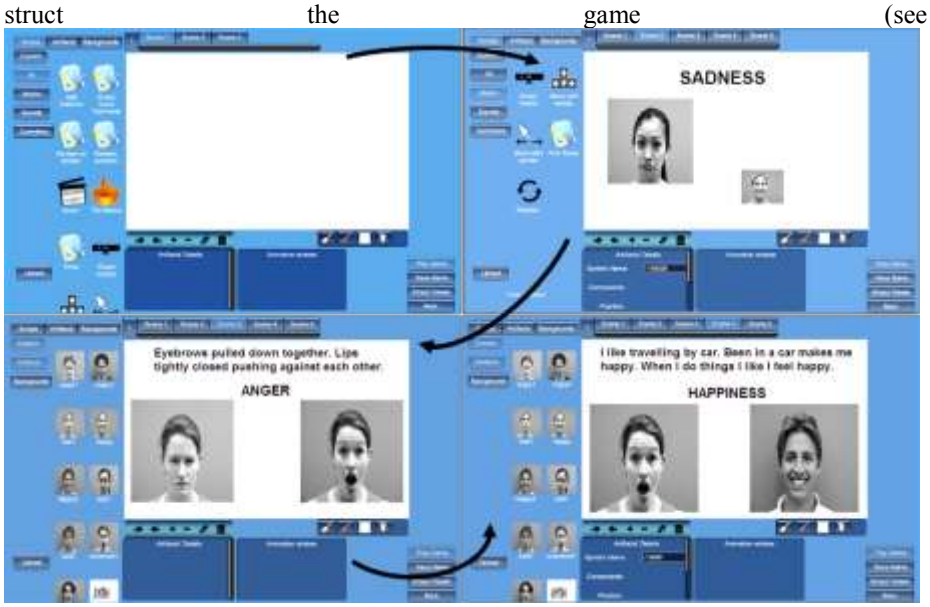

Fig. 9) by using the artifacts and behaviors provided by IOLAOS according to desires and boundaries set up at **step 2**. More specific, in our representative scenario the educational template "Learning Pattern – Autism" has been chosen. This template designates that no colors are permitted when constructing a game (see **Fig. 8**). Following the chosen template restrictions the platform provides only grayscale artifacts to be used in the game. The "Educator" creates a game, based on the generic template "Learning Pattern – Autism" for children with autism diagnosis that fits the specified group abilities and goals, namely emotions recognition. The outcome is a Ludic Educational Game for preschoolers with special abilities and specific educational goals and is presented in detail in the next section.

4.2 Play Game

At the previous section we have described the "Game Compilation" process based on our representative scenario. This section elaborates on playing the game by children with autism diagnosis in their school settings and in supervision by a kindergarten teacher. Detailed results and findings about our survey on preschoolers with ASD which are analyzed into emotional state versus game performance, emotional state versus surroundings, concentration and game performance, and NUI device and game acknowledgement can be found at [**Error! Reference source not found.**].

The game environment is kept simple in order to avoid children's distraction. Individuals with autism are reported to have enhanced perception of details [**Error! Reference source not found.**] which may causes distraction. For these reasons the selected educational template denotes the use of black context presented on a white background and grayscale stimuli. Black and white contrast may also help to increase and retain child's attention and keep them focused on the screen.

Fig. 9. Educator create game **step3**

The game begins with an instruction page (see **Fig. 10**, top left scene1) where the child is informed what is going to happen, what she/he has to do and how she/he can do it. Apart from the text on the screen, audio instructions are also provided. Audio cues are important as the information presented is clear and age-appropriate. When the child feels ready, she/he can choose to start the game. The game provides a structure learning environment which consists of 3 different levels with increasing difficulty (see **Fig. 10**, scenes labeled "SADNESS", "ANGER", "HAPINESS"). Breaking the teaching intervention into small learning steps makes the task easier to perform. In the first level (see **Fig. 10**, scene labeled "SADNESS") children should learn labeling emotions by correlating emotion terms with images. In the second level (see **Fig. 10**, scene labeled "ANGER") they should learn to recognize emotions from their description and their association with facial features. In the third level (see **Fig. 10**, scene labeled "HAPINESS") they should learn to identify the causes of various feelings in different situations, obtained through the use of social stories. Those three levels provide recognition, matching, observation, understanding and generalization of facial emotions.

Computer-based interventions that use a keyboard or a mouse for interaction might cause problem with the younger children which may not be able to use a computer. Our gesture-based interaction approach moves the control of computer from a mouse and keyboard, to the motions of the body via new input devices.

Our game is designed to use non-touch based NUI and to be controlled by hand gestures. The gestures are translated into control commands. The player has three possible actions in all game states, to choose left or right image and move to the next play area. These basic actions are implemented with efficient and easy to use gestures. Moving to the next play area requires a two-hand gesture which is performed by moving both hands above the head. Selecting the left image requires a one-hand gesture which is performed by moving the left hand above head. Respectively, selecting the right image requires a one-hand gesture which is performed by moving the right hand above head.

Fig. 10. Representative scenario [30]

During the game, if the player selects the correct or incorrect stimuli, the system will inform player that he/she gave the correct or incorrect answer. Each answer provides an audio and a visual feedback such as operation-related sounds and appropriate marks above the selected image ('√' for correct answer and 'x' for wrong answer). A voice telling "Bravo" rewards player for the correct answer and a voice telling "Try again" encourages the player to try again when the user provides an incorrect answer. There are no other sound effects because individuals with ASD may suffer from auditory sensitivity [**Error! Reference source not found.**], may demonstrate oversensitivity to certain sounds, even at low volume and may feel discomfort when exposed to certain sounds [33].

5 Conclusion and Future Work

In this chapter we have attempted to sketch the organizational underpinnings of the IOLAOS– a pilot effort aiming to build an open authorable framework for educational games for children by combining ludology and narratology. Our primary design target is to set up an operational model for carrying out the codification of educational theories and learning styles as well as the generation of ludic, narrative, and educational games according to needs, abilities and educational goals and to support this model with appropriate software platform and tools.

Ongoing work covers a variety of issues of both technological and educational engineering character. Some of the issues to be addressed in the immediate future include: (a) Elaborate on the Learning session compiler, (b) Further exploration of learning styles and educational theories in collaboration with expert and educator professional associations, (c) Run various use cases in vivo with the guidance and involvement of

expert and educator professional associations (d) Enhance ludology aiming not only to children experience, but also to experts and teachers, and (e) Introduce further involvement of multimodal NUI devices so that the roles between game player and machine are reversed and the player performs gestures, sounds, grimaces etc. and the machine responds. Moreover, IOLAOS could also offer valuable contribution to develop effective games for rehabilitation. Based on the work scenario presented in this chapter, we have demonstrated the feasibility of using this platform to create Serious Games that combine education and health. Therefore, this operational model must be further studied.

6 References

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