Architecture to Portals of Serious Games and Virtual Environments with Performance Evaluation during Sequences of Activities

Thaíse K. L. Costa[1], Liliane S. Machado[2], Ana Maria G. Valença[3], Ronei M. Moraes[4]

[1]Department of Exact Sciences, [2]Informatic Center, [3]Department of Clinical and Social Dentistry, [4]Department of Statistics

Federal University of Paraiba, UFPB

Paraiba, Brazil

thaise@dce.ufpb.br, liliane@di.ufpb.br, anamvalenca@gmail.com, ronei@de.ufpb.br

Abstract—In the context of teaching and learning in health, serious games and virtual environments can be used as a strategy to support the education process and motivate students by means of different learning styles. The planning and organization for the combined use of these games and environments in a sequence of activities can allow both the diversity of content and the strengthening of the scope of activity. Thus, other important research focus consists in the use of game portals as instruments for integration of resources. Researches show that the services offered by portals can include useful functions to the educational context. Based on this potentiality, the work presents a general architecture for the development of educational web portals that support performance evaluation along the sequence of activities composed by serious games and virtual environments. The work also presents a review about serious games and virtual environments for education and training for health professionals. This piece of research verifies the performance evaluation criteria and the validation types for serious games and virtual environments. We report that the projects, generally, abstract details of the process of performance evaluation, but highlight the importance of this process as well as that of the validation. The researches with this focus support the development of a strong foundation for use of serious games and virtual environments in learning. Thus, the work presents a general scheme for web portals represented by an architecture with support to performance evaluation along the sequence of activities which are composed of serious games and virtual environments. This architecture defines a set of services that can be used to organize and evaluate sequences of educational activities which involve games and virtual environments. In the context of the work, the sequence of activities concerns an organization of activities represented by games or virtual environments, aiming educational objectives. The activities are combined, arranged in hierarchical levels to offer challenges with different degrees of difficulty. The evaluation of the activity sequences is done automatically, however, it is personalized by the mediator. The analysis is performed per level and based on accomplishment of the educational objectives that are selected by the mediator for the evaluation. The educational objectives may be thought of as "the goals of the learning process" and divided in different domains: cognitive, affective or psychomotor. This characteristic is important in the technological context in which the availability of applications such as serious games and virtual environments is observed, addressing skills that go beyond the cognitive domain, like motor skills and internalized values.

Keywords— learning in health; educational portals; serious games; virtual environments

I. INTRODUCTION

In health, the Serious Games (SG) and Virtual Environments (VE) are used for different purposes [1]. For training purposes, they intend to provide a balance between engagement and aspects of learning. Based on their pedagogical objective, these applications combine learning methodologies and evaluation techniques that, when aggregated with the motivational factor, allow users to develop knowledge and skills over the produced situation. Seeking to investigate methods and criteria for performance evaluation, as well as the processes for SG and VE validation as teaching support tools, the article begins by presenting an integrative review of SG and VE oriented to or associated with the acquisition of skills and professional competences.

Besides the particular potential of each SG or VE, it is believed that the planned and combined use these features can allow both a wider range of content and the enhanced learning through the different subjects and learning methodologies that each application employs. Along these lines, an important research focus concerns the use of portals and platforms as aggregation instruments for these resources. Thus, the article also identifies the values of these instruments from a qualitative perspective. The research about portals and platforms enables the characterization of commonly offered services, categorizing them into groups defined by the current authors. In the line of portals and platforms as possible instruments to support the training process, the article also identifies other possible services that could be offered by them as a means to assist the work of planning and the follow-up of activities.

Finally, taking advantage of the benefits of games for teaching and training in health and the potential expansion of the functionality of existing instruments that group SG and VE, this paper presents an architecture for portals able to assist the planning and evaluation of the use of SG and VE with the purpose of training support. The proposal involves the possibility of joint use of different games and simulations in sequences of health training activities, to support the evaluation of users in order to promote performance monitoring based on educational goals.

Studies on the characteristics and contributions derived from SG and VE are important to the area of training in health. Among the works that made surveys on this subject, there are Graafland et al. [2], Bellotti et al. [3] and Nunes et al. [4].

The work of Graafland et al. [2] presents a systematic review about SG and VE for health education, analyzing the application context of these resources for the original purpose. The survey was conducted in April 2012 through the databases PubMed, Embase, the Cochrane Database of Systematic Reviews, PsychInfo and CINAHL. The authors found 25 articles in line with the proposed review, which presented 30 SG, 17 specifically developed for educational purpose developed and 13 for training of surgical skills. From the research, the authors concluded that games and environments can be applied to professional training and need a validation process before being integrated into the curriculum.

The work done by Bellotti et al. [3] shows a narrative review about the educational effectiveness of serious games. Through the research, validation and user assessment aspects in serious games were discussed, recognizing the validity of game-based learning. The authors emphasize that the user evaluation process in serious games is not trivial, because it must include evaluation of performance, important to monitor the development of skills and acquisition of knowledge.

The research by Nunes et al. [4] presents a systematic review of studies of Virtual and Augmented Reality (VAR) published in the Brazilian conference called Symposium on Virtual and Augmented Reality (SVR). The research conducted by the authors shows that the evolution of VAR in health focuses on application development (52 articles), but in recent years it has also seen the growth of works related to the construction of development tools (17 articles) and works related to techniques (9 articles). The works with training objectives, simulation, interactive visualization and rehabilitation, most of them focused on training, were considered 'application development' here.

Seeking further research on the use of these resources, the authors of this article added to previous research data from a new systematic review from other databases, focusing on the identification of characteristics and potential of SG and VE as training resources for students and healthcare professionals. As review objectives, the work highlights the verification of methods and evaluation criteria used in the researches, as well as the investigation on the validation processes of these games and environments as teaching resources.

In the investigation, SG and VE for different platforms (computers, consoles and mobile devices) and oriented or related to the acquisition of professional skills and competencies were considered. The work considered games and training environments for different users in health: doctors, nurses, dentists and others. With special focus on training for professional education, works with exclusive purposes of aiding therapies, health and fitness promotion and health monitoring were excluded from the review. The review also sought to focus on works that presented the overview of serious games and virtual environments for training, excluding items of a more technical nature (modeling, algorithms and techniques used in games or training environments, interaction, lighting, etc.).

The research bases were annals of national and international events in the area: Brazilian Symposium on Games and Digital Entertainment (SBGames), Brazilian Workshop on Medical Informatics (WIM), International Conference on Entertainment Computing (ICEC) and Medicine Meets Virtual Reality (MMVR). Written works in English and Portuguese, published between 2005 and September 2015, were considered. The exception is SBGames, which considered studies published from 2006 to September 2015.

All the titles and abstracts of the papers were read and filtered. The classification done here organized these works into three groups, considering their importance in the context of this review:

• Relevant: when the title and abstract indicated that the article presented a serious game or environment for professional training in health;

• Doubtful: when the title and abstract were not clear, but left evidence that throughout the article a SG or VE for professional training in health would be presented.;

• Irrelevant: when the title and abstract indicated that the article did not address the focus of the review – serious

Every article considered relevant or doubtful was read in its entirety, being then filtered one more time and classified into two groups with respect to the context of this review:

• Relevant: when the article had a serious game or environment for professional training in health;

• Irrelevant: when the article did not address the focus of the review - serious game or environment for professional training in health.

From the new classification and after reading the relevant articles, it was done an extraction of data on the SG and VE, including name, purpose, training styles, user evaluation forms and presence of validation studies. When necessary, further research was carried out to supplement of the information about the works.

Other research characteristics were:

• For SBGames, posters were not considered for the first filtering, due to the paucity of information in the publication.

• For WIM and MMVR, the short papers were not considered for the second filtering, due to the paucity of information in the publication.

The systematic review identified 2642 articles. A total of 55 articles[1] was considered relevant for the research, of which eight had reports of SG and 47 of VE for the training of health professionals. From the 8 articles with serious games reports, nine games were identified. The 47 works on virtual

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[1] Articles list: https://goo.gl/xhtyaO

environments for simulation showed a number of 38 applications, because some articles addressed the evolution or other aspects of the same virtual environment.

The serious games and virtual environments identified were designed with the purpose of training users, being a large portion important for the training of surgical practices (23%) and training of exams and procedures (21%).

A. Assessment Analysis

Based on the objectives of each game or environment, there is a need to explore forms of assessment of the learning outcomes encompassing user evaluation. This type of evaluation is important in applications related to training, as these are designed to support the acquisition of knowledge and / or skill development.

Although most of the applications record few details about its features, the user evaluation is an aspect regarded in all serious games and many virtual environments for training. The serious games, through the union of the nature of games and learning support goals, have scoring schemes that seek to measure the level of knowledge and / or skills of their players. In 66% of the virtual environments identified by this research, there are records of the presence of an automatic evaluation system.

The user evaluation scheme in these games and environments seeks to monitor the choices taken during the training process (correct actions / mistakes and measures). To do this, the applications define (i) the set of considered aspects, (ii) the metrics used, and (iii) decision-making methods and techniques suitable for estimating the performance. The works, though, do not usually detail their evaluation outline, offering only indications of what was done. Within the range of aspects, some, cited by the works, are:

• Order of the performed tasks

• Time for completion

• Exactness of different types of decision

• Adequate use of instruments

• Precision in the performance of the procedure

It is important to emphasize that the entire set of aspects, metrics and statistics is selected based on the goals of each game and environment, as well as on its training style. Therefore, the importance of the participation of experts during the planning of the evaluation module is reiterated, which has been identified in most of the researched papers from the identification of authors.

Among the 34% of virtual environments that do not register the presence of a module for automatic user assessment from the application, there are projects that indicate the possibility of insertion of this module as future work, or that report the realization of this evaluation in a non-automatic form, after or during training, by analyzing records or by presential specialist monitoring, respectively.

B. Validation of the serious games and environments

The verification of achieved capabilities through the serious games and virtual environments is generally performed by a validation process that requires planning and time. Of the 47 applications included in this review, 25 have gone through a validation process. Each process differs in (Figure 1):

• Amount of groups used for the validation experiment

In the review, the existence of works that perform the validation experiment with one, two, or three user groups was identified.

• Types of user per group

It was observed the presence of three types of groups: experimental, control and specialist. The experimental group consists of members undergoing training through the use of the game or environment, the control group consists of members subjected to another or no kind of training and the expert group consists of experts in the content covered by the game or environment.

• Aspects validated in the experiment

These aspects relate to the performance goals, functionality, acceptability, feasibility, realism and usability.

From the analysis of the 25 works, we identified 7 "paths" to perform validation, varying according to the terms presented. In Figure 1, these paths are named from A to G. The figure also shows the number of occurrences (frequency) of each form of validation, i.e., the number of works that follow similar paths. There is a higher frequency of works that validate their games and environments according to aspects of feasibility, realism, usability and functionality by means of an experimental group, followed by works that validate their applications from the standpoint of the performance of its users, comparing an experimental group with a control group. In the latter case, after the period of training, an evaluation is done to identify each participant's level of performance. With this, the expected results from the experimental and control groups are verified and compared. In applications that performed this validation process, it is possible to notice that the experimental group presented a better performance when compared to the control group, which indicates the benefits of using games in training activities.
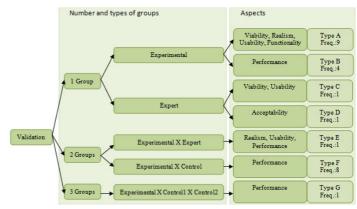

Fig. 1. Validation processes identified in the articles.

These forms of verification of games and environments suggest that the aspects analyzed in each experiment are valid. In general, regardless of the path chosen to perform validation, the results were positive. Only the work that used the validation of type G [5] registered a similarity of performance between the experimental group and one of the control groups, which used a traditional training technique. Nevertheless, the study recommends the use of the application as a means of training, highlighting as an advantage the objective assessment scheme that does not require the presence of the instructor.

III. POTENTIALITIES OF SERIOUS GAMES AND VIRTUAL ENVIRONMENTS IN TRAINING PROCESSES

As observed in the researches, the SG, as well as VE, are well accepted in the fields of professional training in health. They can address case studies, offering ways to (re)train specific tasks, conduct tests and evaluate performance of users. These applications can be used as complementary resources to the educational process, adding opportunities and benefits that are not always be covered by traditional training methods with the use of guinea pigs or practice on real patients.

Studies show that each game or simulation often addresses content with well-defined scope. In this context, the authors believe that thinking about the joint use of SG and VE that have complementary or similar goals in a planned way allows a closer approximation of these resources to the pedagogical practice. Currently, the planning of activities with these resources, in most cases, requires from the mediator a research of the applications scattered on the Internet and the investigation of their characteristics and objectives to, then, gather them and use them with their students, without having tools to assist the planning and monitoring of the realization of these activities.

Along these lines, an interesting focus of research is related to the development of computational tools that can assist the application of SG and VE, helping to integrate this training strategy to the curriculum. These instruments, such as portals or platforms, can provide different types of useful services to the training context [6].
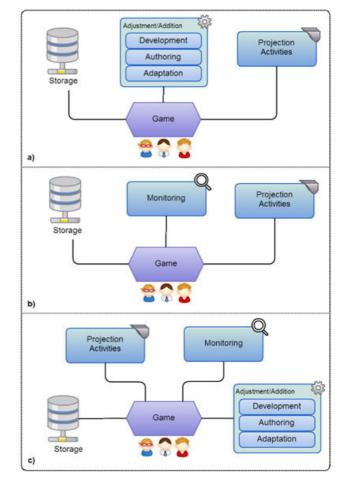
Among the works of this nature, it is possible to cite Pingo (Portal of Instructional Games, Online) [7], the Attractive Virtual Educational Portal (AVEP) [8], the Simurena platform [9], the mGBL platform (Mobile Game Based Learning) [10], the portal Games and Simulation for Healthcare Library and Database[2] and the Portal for the Aid to the Treatment of Bamidis [11]. Although not all of these portals or platforms are applied in the health field, they exemplify instruments that aim to unite games or virtual environments that seek to aggregate useful services to the educational context.

These portals and platforms highlight four main services:

i. Storage: service responsible for the registration of information and research of games and simulations in the instrument;

ii. Adjust or Addition: service responsible for allowing the insertion, modification, or creation of new games and simulations through the portal;

iii. Projection of activities: service that enables mediators to create activities, including the selection of games and simulations for apprentices / patients;

iv. Monitoring: service responsible for user performance record, with possible generation of report;

In the cited works, it is observed that these services are combined in different ways, shown in Figure 2. Only the portal Games and Simulation for Healthcare Library and Database offers no combination of services, providing just the storage of information for research and access to games. In the Simurena platform, it is possible to identify the combination "a" exposed in Figure 2, which includes services of (i) storage, (ii) adjusting or adding and (iii) projection of activities. In the Attractive Virtual Educational Portal and the Portal for the Aid to the Treatment, the configuration "b" from Figure 2 is observed, constituted by the service of (i) storage, (iii) projection of activities and (iv) monitoring. In the portal Pingo and the mGBL platform, the configuration "c" from Figure 2 is identified, composed by the union of the four services. Among the services, the work highlights the (iii) projection of activities and (iv) monitoring. They are important for planning and monitoring the training process, respectively, being outlined in different ways.

Fig. 2. Settings of the services provided by the platforms or portals. (a): storage, adjustment or addition, and projection activities; (b): storage, monitoring and projection activities; (c): union of the services: storage, adjustment or addition, projection activities and monitoring.

It is important to emphasize that the 'projection of activities' can offer the possibility of 'horizontal planning' of activities for learning, 'vertical planning' of activities for learning (activities of different levels) and hybrid planning. In the 'horizontal planning' it is assumed that the activities are at the same level of complexity or similarity of goals, with no prerequisites among them. In contrast, in the 'vertical planning' it is assumed that the activities have different levels of complexity or differentiation in their goals. Thus, mediators can compose a learning sequence with an increasing gradient of complexity and knowledge appropriation. Finally, in the hybrid context, the project of activities may be proposed as an arrangement between the other two forms of planning. [6]

This article also highlights the 'monitoring' service, which involves the use of machine decision processes to assist the verification of user performance. This service can provide two forms of performance information: (i) give information about the user's performance by each game or simulation, or (ii) give performance information analyzing aspects of various games or simulations for a combined assessment (general), which may be useful in activity management.

Based on this information, an attempt was made to determine which forms of 'projection of activities' and what 'monitoring services' were provided on each platform and portal investigated. Table I summarizes the information collected, with the columns representing:

A. Horizontal planning of learning activities

B. Vertical planning of learning activities

C. Performance verification by game of simulation

D. Performance verification with aspects of more than one game or platform

TABLE I.   SERVICES OF 'PROJECTION OF ACTIVITIES' AND 'MONITORING' OF THE WORKS PRESENTED

Portal/Platform	Projection of Activities		Monitoring	
	A	B	C	D
Pingo	Yes	No	Yes	No
AVEP	Yes	-	Yes	-
Simurena	Yes	No	No	No
mGBL	Yes	No	Yes	No
Games and Simulation for Healthcare	No	No	No	No
Treatment Platform	Yes	-	Yes	-

The blank spaces in the table represent the omission of explicit information about the analyzed feature. Thus, from Table I, it is clear that the possibility of vertical planning of activities for learning is still not a feature exploited by these instruments. Note also that user performance analysis,

considering aspects of various games or simulations to provide a more general evaluation is not contemplated in these portals, which suggests the possibility of including and adapting this service is a potential search space.

Even if the research has not found game portals and VE for professional training in health using a monitoring service, it is believed that the inclusion of machine decision processes in these health portals would enable the monitoring and evaluation of the performance of users (students) helping mediators in the training process based on the use of games and virtual environments. The inclusion of this and other services in the game portals and VE contributes to the use of these instruments to support training and takes away the idea that the portals are used only for storage resources.

IV.   ARCHITECTURE TO PORTALS OF SERIOUS GAMES AND VIRTUAL ENVIRONMENTS: ORGANIZATION MODEL AND PERFORMANCE EVALUATION

In the scope the conducted investigation, the portals for grouping SG and VE do not have original focus on professional training in health. The presented instruments propose services and settings that can be adapted to the context of health and structured to assist the professional development process. This fact reveals a potential search space that can both assess needs and adjustments to the current services and expand existing services according to the requirements for training these professionals.

In this context, the present work expands the service of 'projection of activities' in order to make the vertical planning of activities for learning viable, as well as the hybrid. This way, besides organizing a simple set of activities (SG and / or VE), mediators can also plan didactic sequences with the possibility of gradual increase of complexity and / or skills to achieve general educational goals. This new possibility of organization also leads to expansion of the 'monitoring' service, which needs to analyze and combine the objectives of different games or simulations to measure the level of performance in a more general context.

Thus, we present a general scheme for web portals through an architecture that supports user performance evaluation from the sequencing of activities (trial of activities), in the context of SG and VE. The architecture contains textual descriptions and models that demonstrate the objectives, assumptions and aspirations for portals of management and evaluation of activities involving the use of games and virtual environments. The description documents and presents the essential elements so that, from this abstraction, portals (use cases) that implement the proposal of performance evaluation from the activity sequencing be implemented. It also seeks to identify potential users of the system, showing its main interests.

A. Assumptions and Guidelines

The architecture represents a general scheme for web portals that provides a set of services and mechanisms that can be used by the mediator to organize and evaluate sequences of educational activities involving the use of serious games and virtual environments. The idea is based on the following assumptions:

- Students and professionals can capacitate themselves through games and virtual environments focused on the support and learning of specific content.
- Games and virtual environments that are concerned with educational support are focused on specific issues and have educational goals set for different dimensions of knowledge (cognitive, affective and psychomotor).
- Games and virtual environments that are designed for educational support can be grouped to treat different subjects or emphasize similar subjects from multiple forms of presentation.
- Mediators are responsible for guiding the educational process, so they can organize sequential sets of activities as trails for learning. The activities are translated into serious games or virtual environments for educational support.
- As mentors, mediators can define the educational objectives to be evaluated, so that students can go through the learning trail gradually, as they show knowledge of the intended objectives.
- As mentors, mediators can define other elements to be evaluated in parallel to the educational goals.

The proposal is that this architecture helps the mediator integrate games and simulations to the planning of their teaching actions, as well as evaluate the performance of users during activities. Thus, the architecture definition efforts follow the following general guidelines:

- Serve as educational support, enabling performance evaluation during the activity sequencing;
- Allow the use of games and virtual environments as activities for educational support;
- Allow mediators to build custom activity sequences for classes;
- Allow mediators to define the evaluation for each planned sequence of activities, based on educational goals;
- Allow mediators to include assessment results based on parameters of the activities carried out in trails;
- Allow students to perform the activity sequences and monitor their performance;
- Enable mediators to track student performance;
- Enable developers to request the inclusion of new games or virtual environments to the system;
- Allow access to the system via Web;
- Enable the use of the idea of sequencing and evaluation by portals for different use cases.

B. Sequencing and Evaluation

In the context of this work, the activity sequencing consists in organizing tasks and / or content planned by the mediator, according to the educational objectives to be reached. The activities that make up the sequence correspond to the serious games and virtual environments that can be selected, collected and arranged in levels of complexity, as seen in Figure 3.

The levels are hierarchical and each one is formed by a number of games and / or environments. Because they are hierarchical, the progress for a subsequent level is only achieved when the minimum requirements of the current level are accomplished. However, the games and / or environments grouped in a same level do not have restrictions regarding the order of realization.
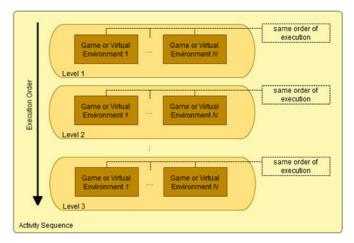

Fig. 3.   General composition for a sequence of activities

Mediators define the minimum requirements so that the student can pass the level, and these requirements are represented by minimum values of performance in categories of learning domains, depending on the intended goals. Upon completion of the sequence, the students demonstrate they have complied with the minimum requirements and that they have achieved the trail's purpose.

Figure 4 shows an example of a trail of activities that consists of three levels. The first level consists of four activities (games or environments), the second level of three and the last level of two activities. Games and environments that appear on the first level can be performed according to the preference of the student, but the realization of the activities that belong to the second level is only possible when the student reaches the minimum performance (specified by the mediator) in the first level. The process is repeated for the other levels of the sequence, allowing the mediator to plan activities that require different levels of knowledge and complexity.

In the proposal, the sequencing must be planned and guided with the objective of providing a specific learning through experimentation and training with games and environments. The activities will be sequenced with the intention of offering challenges with different degrees of complexity. These sequences may be derived from content extracted from one of the topics discussed in the teaching-learning process in health, appropriate to the context and planned by the mediator, so that each sequence of activities can be directed to a student or group of students.

The evaluation of the activity sequence is performed automatically, but must be customized by the mediator. Each mediator, when creating the sequence of activities for a student or group of students, can customize the evaluation process, considering the learning objectives desired for such sequence. Thus, from the information sent by games and

virtual environments, the performance of each student is monitored based on the taxonomy of educational objectives.

According to the focus of the created sequence, the mediator can choose which categories of learning domains are considered in the analysis, as well as set the minimum degree of success by category for completion of a level of the sequence. This selection and restriction of the minimum levels of success by categories allows the reinforcement and the requirement of further training by the student in aspects desired by the mediator.
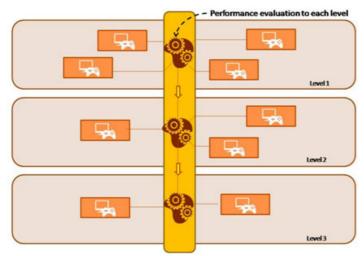

Fig. 4. Example of trial of activities.

C. Abstraction Level

The vision in levels for the architecture can be divided into three layers: i) presentation, ii) activities and mechanisms for evaluation and iii) management (Figure 5). The 'presentation' level is the interface between users and environments, through which the information is displayed. This level consists of two sub-levels: browser and components handled at the level 'activities and evaluation mechanisms', i.e., representations of computational abstractions that are available features or activities (games and educational virtual environments).

Fig. 5. Levels of abstraction.

At the level 'activities and evaluation mechanisms', means of support for the environment's requirements are found, such as communication, information extraction and customization of the sequencing of activities and evaluation. At the level of 'management' are facilities for storage, management and data processing.

D. Module View

The modules that make up the overall architecture are shown in Figure 6. In the figure, six modules can be seen: assessment, database management, administration, developer, mediator and student.
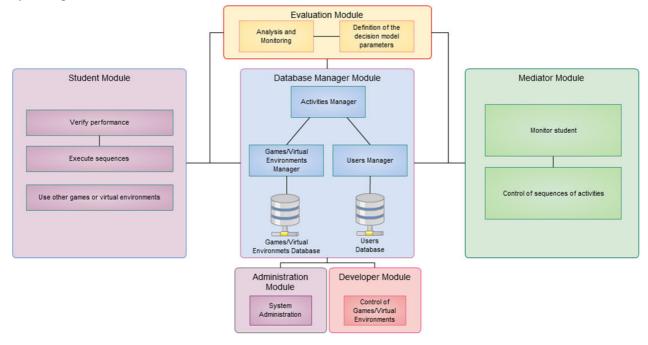

Fig. 6. General Architecture.

The database management module contains the system managers and databases, being divided into: user manager, game/environment manager, activity manager, bank of users and bank of games/environments. The user manager is responsible for controlling the user bank, which stores information of developers, mediators and students. This managing submodule controls the creation, modification and deletion of records of users. The game and environment manager is responsible for controlling the database that stores these resources (bank of games and environments). This managing submodule controls the registration, modification and deletion of available applications. In order to control the relationships among resources and users, there is the activity manager. This manager will receive requests from other modules and manage the communication with the user manager and the game/environment manager.

The developer module will be responsible for the request of registration for games and environments and, for this, it will communicate with the database management module and the administration module. In addition, it will allow the developer to access information from registered games and environments. The administration module will be related to the developer and database management modules, being responsible for the examination of registrations for approval of new features.

The mediator module must control the actions necessary for the creation of sequences of activities, as well as the administration of students and classes, communicating with the manager and evaluation modules. The student module will allow students to access activity sequences, enabling their realization. This module will also allow access to games and environments individually, through calls to the administration module. In addition, through this module, students who lack guidance will be able to request help from a mediator.

Finally, the evaluation module is responsible for customizing attributes of evaluation for each sequence of activities, acting, in this context, together with the mediator module. In addition, the evaluation module will also conduct a performance analysis of the student during the sequence, requiring a joint action with the student module.

V. CONCLUSIONS

In the field of serious games and applications for health, the current study ratifies the importance of user performance evaluation and highlights the particular character of how this process is performed in each application. Every serious game or virtual environment has well-defined objectives, which directs and generally individualizes the assessment process. There is no standard model followed, but there is an end in common: the verification of the scope of the educational goals of the application.

Thus, regardless of the form of assessment used, it is interesting that these applications are validated by its users and / or experts. The review confirms that not all serious games and virtual environments are validated for the purpose of use, and that the works choose different paths and validation purposes. However, from the perspective of educational support resources, it is essential that applications consider this aspect in the validation process.

The architecture presented here highlights the potential of the combined use of serious games and virtual environments in the health education process. This architecture enables the planning of activities and of the evaluation process based on educational goals to be reached. It provides a different way of collaborating with the training of human resources through the proposed sequencing of games and simulations, allowing a chained composition of activities that provide the reinforcing or complementation of tasks and content in progressive scale.

To provide a more general assessment, the architecture considers the achievement of specific educational objectives of each application. It values the result of user performance evaluation with a focus on goals pertaining to the particular context of the application, not the way that the evaluation process was internally conducted in a given application (VE or SG). Because of this, it values the need for validation of games and environments considering their purpose of use.

In particular, this approach of joint use of games / simulations with the more general assessment of the sequence of activities is interesting because they allow the analysis of skills in different domains (cognitive, affective and / or psychomotor) through the union of activities. This characteristic is relevant in a technological moment in which there is the availability of applications in the form of games and virtual environments that address skills that go beyond the cognitive domain, such as manual dexterity and internalized values.

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