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Improving Motivation in a Haptic Teaching/Learning Framework*

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Virtual reality simulators represent an affordable alternative for teaching and learning specific skills in environments not available in reality for educational purposes. Their goal is to provide a simulated environment where students can practice real tasks in a safer way and with no real consequences in fields as engineering or surgery. For a simulator to become a more complete teaching and learning tool, it should also include the expert knowledge required to provide instant feedback to the user. SHULE is a framework for building haptic simulators to be used with educational purposes that includes expert knowledge. In order to increase users' motivation, we have also considered game features in the framework design, development and integration with other tools. This process includes the elements needed to provide a challenging goal for the simulator with the correct amount of uncertainty that would increase user's curiosity enough to keep on using it until certain skill is achieved. Simulators produced with SHULE can be integrated with a Learning Management System (LMS) such as Moodle by means of web services. Their functionality offers the teacher the possibility to create new activities to be performed at the simulator, and also offers the students the possibility to see the results of their simulator sessions in the LMS.

Keywords: haptic simulator; e-learning framework; gamification

1. Introduction

In 2011, in a conference about envisioning future media environments, MindTrek'11, Sebastian Deterding et al. proposed the most commonly accepted definition for the term gamification as the use of game design elements in non-game contexts [1]. Games are no longer just games. They can be much more. We want them to be much more and in a possible future described by Jesse Schell games will even help us being better persons [2]. By now, according to the last Nielsen 360 Gaming Report, in U.S., people older than 13 spent 6.3 hours a week playing video games in 2013[1]. Why do people spend such a big amount of time doing that? Maybe the reason is the one that Schell states in his talk; they do not *have* to do it, they *want* to do it. If we change the context from leisure time to formative stage, then we would like learning to be a want-to-do task. In other words, we would like to improve the motivation for learning.

In his study about computer games in 1980, Malone identified three main categories for a motivating instruction: challenge, fantasy and curiosity [3]. Challenge implies that there is a clear goal to achieve and the way to do it is somehow uncertain with different levels of difficulty that vary over time. To stimulate curiosity, the environment should be neither too easy, for the user not to feel bored, nor too complicated, for the user not to abandon. The third category, fantasy, is becoming more and more real nowadays, with games attached to reality, such as Mafia Wars on Facebook attached to real persons, Skylanders attached to real character figures, or the Kinect attached to real person's movements. Virtual reality can provide the fantasy of being in the real world, and the addition of the sense of touch, besides vision and audition, helps making the experience more immersive.

SHULE is a framework for building virtual reality haptic simulators to be used as teaching/learning tools [4]. The framework has been designed in such a way that developers of each new simulator can focus on the specific environment to be simulated. Design patterns [5] have been used to provide a common architecture for representing complex tasks. The requisite for these tasks is that there should be a sequence of steps for it to be fulfilled. Although the sequence is unique, the set of actions inside each step of the sequence are only limited by the user will and the tools provided. The architecture addresses also the mechanisms for including expert knowledge that allows rich feedback both for

[1] http://www.nielsen.com/us/en/insights/news/2014/multi-platform-gaming-for-the-win.html

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the student and for the teacher about users' performance.

The real success of a simulator for teaching/learning comes when students use it. For increasing users' motivation, game features have been included in the framework design, development and also in its integration with other tools. The simulator guides the user while trying to achieve the goal offering continuous feedback about her performance. This feedback is processed from the expert knowledge information provided by the domain expert in the analysis phase. The analysis phase is guided by the framework architecture, which defines the information to be obtained from the expert and it also establishes the structure of that information. Once this information is obtained, it is directly transferred to code. Developers can skip the design phase because the framework architecture has already settled it. This way, developers can focus on the problem.

Although the framework does not cover cooperation between users to perform tasks by now, we are presenting in this paper our proposal for improving the motivation to our framework by means of a Learning Management System such as Moodle. Simulators for teaching and learning are presented as a very valuable tool to complement traditional teaching. To be treated as such, we need to offer an interface to integrate them with LMS's. By means of web services this integration is made independent, so that an activity for training using a simulator can be created in the LMS, and the results of the user performance in the simulator can be transferred back to the LMS. Showing the results of all the students for this training provides the competition factor.

The paper is structured as follows: section 2 describes the background context in which the work is set and shows a brief review of related works, section 3 offers a brief description of the framework, and section 4 details how the framework can be integrated with other systems. The paper ends with some conclusions.

2. Background context and related work

SHULE is a framework that was conceived as an architecture for building haptic simulators to be used as teaching/learning tools to transmit expert knowledge. And, particularly, there is a special kind of expertise that involves the use of hand skills and both visual-spatial and bodily-kinesthetic intelligence [6]. It is believed that, in virtual reality scenarios, the advantage of the addition of haptics lies in its ability to tap into the users' kinesthetic memory. That is, our ability to remember limb position, spatial orientation, and velocity [7, 8]. Haptic systems are mainly used in engineering and surgery, and engineers are more likely to be active than reflective learners, and the active learner has much in common with the kinesthetic learner [9], which lead us to focus mainly on engineers and surgeons.

1. For engineers, our focus is on assembly process because, on the one hand, its cost often account for more than 50% of the total manufacturing process [10] and, on the other hand, building physical prototypes is a very costly process not affordable for most high education institutions. The authors of [11] use virtual reality in real-life practical case studies showing how this technology can be employed to produce creative learning and training engineering material and environments. They expect that additional institutes will implement the necessary hardware and software level for virtual reality to be strategically adopted in the future of engineering education. In this sense, our proposal implies a step toward this goal by adding one important part to virtual reality simulators: the domain expertise.

   Domain expertise has not yet been incorporated in the assembly simulators reviewed in [12]. Methods such as the ones proposed by computer-aided assembly planning rely on detailed information about the product geometry, but they do no account for the expert knowledge held by the assembler that may impact the design process. The use of virtual reality for assembly has long envisioned that providing access to other expert's knowledge, the designer is able to make better design decisions and also extends the designer's knowledge [13].
2. For surgery, classic simulation uses physical models to recreate the elements of a surgical procedure. Those models are mannequins, cadavers or living animals. The main advantages of using physical models are their relative low cost and their versatility. Nevertheless, these models have several limitations. They suffer logistical problems, as availability or material reuse, and even ethical problems, as those related to using cadavers or living animals. Although its importance in the learning process is undeniable, this type of simulation is becoming obsolete in some situations [14] and virtual simulation has showed to be more suitable to cover the needs of new generation regarding surgical procedures [15]. In addition, the main problem observed is the lack of a feedback component that allows the student to know and feel the anatomy of a real element

(tissue or organ), while measuring and evaluating the student performance during the surgical procedure in the absence of the continuous supervision of an expert.

Domain expertise has not been incorporated in surgery simulators either. The nearest approach is the CyberMed system by offering an on-line method to assess the user's performance [16]. But expertise information is required for providing feedback to the user. According to Hattie and Timperley [17], feedback has tremendous impact on learning gains, both positive and negative. Our proposal for that feedback to be a positive one is to use game elements. Adding game elements to not attractive tasks, such as calibration, has made them strongly preferred by users than the standard version [18]. The meta-analysis carried out by Merchant et al. showed that, in general, game-based learning environments were more effective than virtual worlds or simulations, with overall effect sizes that were roughly twice as large [19].

In a ten-year critical review of empirical research on the educational applications of Virtual Reality [20], authors found that haptic systems were still expensive and used mainly in applications like surgery and engineering. A surgery application has been chosen for this paper because of several reasons but, mainly, because of its inherent high expertise level. The particular example used is the cataract surgery. On the one hand, developing a surgery simulator involves two types of users: the surgeon as an expert, and a computer engineer as the system builder. On the other hand, producing haptic simulators for surgery is equivalent to generating them for assembly. The main differences are that the human or animal anatomy has to be changed by, for instance, an engine, and the representation of the expert knowledge in each case. For surgery, the expert knowledge is mainly related to the anatomy elements modifications, and for assembly, the expert knowledge is mainly related to the relative position and order of the assembly parts.

In the next subsections, a brief introduction to haptics is shown and the use of haptic simulators in surgery is shown as an example of the extended use of this type of devices. Next, serious games are commented and the section ends outlining the current deficiencies.

2.1 Haptic simulation

As Srinivasan explained in [21], the word *haptic* refers to the interaction with the sense of touch with the intention to perceive or manipulate objects. Those interactions may differ depending on the context where they take place; real or virtual. They can be intended to create virtual objects inside a simulation, to control those objects or to control real objects remotely.

The haptic technology provides to the sense of touch the same feedback that computer graphics provide to the sense of sight. Computer displays allow the eye to see what happens in a virtual environment, haptic interfaces allow the sense of touch to feel the objects in the virtual world. Usually, in order to create that sensation, a specific type of device, or haptic interface, named *force feedback*, is used. Those interfaces create force fields that resist the movement of the hands or body of the user. They recreate the physical and material properties of the virtual objects; their shape, texture, weight, etc.

Being able to see, hear, touch and modify a virtual environment, allows the application of VR to many real life problems. For instance, Fager and Wowern stated that a VR simulator can be used to improve the learning curve of some surgical procedures and also to train psychomotor skills [22]. Furthermore, Calatayud et al. in [23] and Coles in [24], showed that the inclusion of haptic interfaces improves the usefulness of any surgical procedure because touch is more important than sight in this area. As described before, the "force feedback" created by a haptic interface allows to feel the haptic signals generated by a computer. This improves the level of immersion and thus, allows a student to feel part of the virtual surgery; this way, the student can measure the patient's pulse rate, measure the hardness of a tissue or organ, know how to handle surgical tools, etc.

Many works show that the use of haptic interfaces inside VR simulators improves the performance of students, during the first stage of their education [26–29]. Using haptic simulators, surgical training is more effective than other methods because it helps in the development of psychomotor skills. Today, haptic simulation is used for surgical training in different fields: simulate the physical properties of tissues and organs [30][31], train surgical skills and faithfully replicate surgical procedures, etc.

In [24] Coles states that almost every surgical specialty has its own haptic simulator, with Minimally Invasive Surgery (MIS) being the most demanding. Laparoscopy (a kind of surgery performed through small incisions) is the most well known. This surgical technique heavily relies on touch, because the surgeon's vision is restricted to the use of a small camera. One of the best examples of haptic simulator is the LAP Mentor from Simbionix. The simulator is composed of a workstation with a screen, two haptic interfaces that replicate the laparoscopic tools and another tool for the laparoscopic camera. The simulator's software provides a learning module for training psychomotor skills (like tying knots or stitching wounds) and for replicating some techniques (gastric bypass, nephrectomy and hysterectomy, etc). Salkini et al. [32] and Lucas et al. [33] showed that these haptic simulators benefit the students during their training stage. At the simplest level, there are "low-cost" simulators like VBLaST [34], which uses two off-the-shelf haptic interfaces.

Another kind of MIS technique is the endoscopy (performed through natural cavities), which also features many haptic simulators. For instance, the work of Tolsdorff et al. [35] shows a simulator for a paranasal sinus surgery using common hardware (PC and off-the-shelf haptic interface) and the work of Perez-Gutierrez in [36] describes the creation of a haptic interface to use with a simulator for endonasal surgery training.

To a lesser extent than the previous examples, haptic simulators are featured in other surgical specialties. For instance, in [37] Choi details a "low-cost" haptic simulator for cataract surgery training. There are also works about bone surgery like a haptic simulator for mandibular angle reduction by Qiong et al. [38] or a temporal bone simulator by Fang et al. [39] for both, anatomy and surgery training. Another frequent type of procedure is dental surgery, with simulators for dental training and skill assessment [40–41].

Nevertheless, haptic simulation is not only applied to surgery; other medical procedures like palpation, puncture or biopsy are subjects of study and research. Examples of these procedures can be found in the work of Ullrich [42] which presents a palpation simulator for practicing regional anesthesia; in a haptic simulator for diagnosing liver tumors created by Hamza-Lup [43]; in a haptic simulator for performing biopsies by Dong et al. [44]; or in the work of Goksel et al. [45] which describes a simulator for training the needle insertion of a prostate brachytherapy procedure.

2.2 Serious games

Before using a VR simulator as a teaching-learning tool, it needs to provide some kind of mechanism that motivates final users to use it. It is worthless to use the latest technology available to get a high level of realism if the simulator cannot transfer its knowledge to the user, as it will not make any difference from other options.

Gamification is a new learning concept that is getting importance in different fields [46, 47]. This term refers to the use of different videogame elements (e.g. score, goal achievements, overcome some obstacles, etc.) inside a context that is not designed with that purpose. The combined use of game mechanics and interactive applications (a computer simulator) in a learning context is called a "serious game". As described by Chen in [48], a serious game is a videogame that both entertains and has a serious purpose like teaching a subject or helping to take decisions. For this purpose, a serious game provides the immersion feature of a videogame and motivates the user to achieve some goals through rewards.

2.3 Current deficiencies

Although there are lots of works done in this area, the main problem that VR simulators (and thus, haptic simulators) show today is the lack of a standard methodology that allows to teach and/or learn surgery in an efficient way.

Most of today's VR simulators can be considered "static" because they are designed with the single purpose of training a specific surgical procedure and they are not capable of adding its own feedback, i.e. adding the information obtained from the use of the simulator and from the expert's knowledge. Such information would add extra value to the simulator over other traditional options.

As stated by Hamza-Lup in [49] and Ruthenbeck in [50], current research works in this area are isolated between each other, and their development is done by combining different basic components and off-the-shelf haptic interfaces. This situation leads to having a bunch of different programming libraries and work environments. Besides, the integration of the haptic component into a simulator is not mature enough because currently there are no stable software libraries to handle them.

These shortcomings that can be extrapolated to engineering lead to the necessity of creating a haptic environment for both learning and teaching complex procedures, and to be used as a tool to revolutionize medical and engineering education.

3. Framework overview

SHULE is a framework for building haptic simulators to be used with educational purposes that includes expert knowledge. A framework such as SHULE has implicit complexity. Inside SUHLE design, each procedure is considered as a sequence of steps. For each step, a state machine represents all the possible actions that the user can perform depending on the tool used inside that step. Selecting a new tool implies changing from one state to another one. For instance, for the capsulorhexis step, the second one in the cataract surgery using the phacoemulsification technique, the state machine includes five states. Four surgical tools can be used during this phase and eleven elements of the anatomy of the eye are involved. For every possible transition from one state to another one, three pieces of information are collected; Information to provide feedback for the student, outcome for the instructor and positive or negative marks to compute the final score.

SHULE is an object-oriented framework that has been developed using design patterns in order to provide a flexible, maintainable and reusable solution [5]. Thanks to the use of design patterns, the code is simplified and responsibilities are clearly defined for each class. Even though the patterns help clarify the code and provide an already set design that allows developers to focus on the simulator functionality, for the particular case of the capsulorhexis step, five new states, three new visitors, eleven anatomy elements and three new observers have to be created, as well as the three types of information associated to each state change.

This apparent complexity allows expert knowledge to be incorporated into the simulator straightforward. Developer's duty is to complete a set of tables where the domain expertise is captured. Once those tables are fulfilled, the framework architecture indicates where to place each piece of information into the design and, therefore, into the code.

That expert knowledge is what allows SHULE to integrate some game elements. Following the instructional design proposed by Malone [3], two of his three categories have been considered to improve motivation; challenge and curiosity. The third one, fantasy, has become virtual reality, in other words, a fantasy of reality. These are the elements included in the framework for each category:

Challenge category

- Meaning: There must exist an object of the game, its goal, and its achievement must include some degree of uncertainty.
- Elements:
  a. User identification: For the goal to be personally meaningful, the user has to be identified herself with the actions taken into the simulator. Example: The simulator shows the user name and role all the time: "Designer: Mr. Smith", "Surgeon: Mrs. Jones", etc.
  b. Explicit description of each step: For the goal to be obvious so that the user does not get lost. Example: "Step 2: Capsulorhexis—Tear apart a circular section of the anterior lens capsule".
  c. Scores shown constantly: For the user to have permanent performance feedback information. Example: A progressive bar shows if the user is doing better or not during the simulation.
  d. Level of expertise: Automatically determined by the simulator depending on the user performance. Example: The user starts with apprentice level and will go through junior and senior to become a master.
  e. Skill levels: A difficulty level is assigned to each scene by the expert and expectation levels increase for higher levels, where best performance is linked to less time. The teacher decides the criteria to promote from one to the next. Example: Fundamental, intermediate and advance levels, where the student has to perform very good in at least 30% of the scenes to promote to the next one, or perform just good in at least 75% of them.

Curiosity category

- Meaning: The environment should be neither too complicated nor too simple with respect to the learner's existing knowledge. Our environment is to be used as a teaching-learning tool together with traditional classes and the expectations will be clearly stated at the beginning of the procedure, for instance, 'cataract surgery using phacoemulsification technique'.
- Elements:
  a. Audio, visual and haptic feedback: To promote sensory curiosity in the user. Example: Visual—the eye anatomy, audio—sounds of the vital signs, haptic—feeling of tearing the anterior capsule.
  b. Informative feedback: To encourage user curiosity, not only information about what is wrong is provided, but also the reasons for that. Example: "Shape of the opening includes a corner. A corner can provoke tissue tearing. Corners must be repaired".

In the next section, the integration of SHULE with Moodle is shown in detail specifying the role of each of these elements in the process.

4. Integration of tools

SHULE can be considered as a framework that offers a teaching component, where the expert knowledge is transferred to the simulator, and a learning component, where the expert knowledge is supposed to be transferred to the student.

1. The teaching component is responsible for offering a mechanism that allows an expert to generate customized surgical training scenarios. These scenarios are designed by an expert and describe the different learning objects involving a certain complex procedure, that is, the scene, the objectives to achieve, the actions to perform, etc. The key feature of these scenar-

ios is that they collect information of the user's performance for evaluation purposes. Such information will help the expert to check the validity of the training scenario, and modify it if needed. This design aims to prevent any communication problems between the experts and the developers, saving an important amount of time.

2. The learning component is provided by a haptic VR simulator that is able to load the custom training scenario so the students can practice. The use of the simulator will be like in a real practical session: the simulator will guide the student through the different steps, giving visual cues for the actions performed in the scenario. During the performance, the haptic component will give the student the feeling of touching the virtual elements, aiding in the development of psychomotor skills. Also, after the performance the simulator will give the user a detailed report about her evaluation.

To implement the elements of the framework, a software component named Simulator is being developed. The Simulator comprises two components:

1. HLogic, which is the core of the simulation. It contains the software model that is able to handle the execution of the training scenarios. This component is programmed in C++ and implements the logic of the framework.
2. HBOgre, which is the application itself. It is based on the OGRE3D game engine [51] and it has been developed in C++. This component adds support to haptic interaction and is also in charge of collecting the data used to evaluate the user's performance. However, the key feature is that it runs the simulation itself and loads the custom training scenarios.

With these elements, the integration with Moodle has been addressed.

4.1 Integration with a LMS

The key to the integration of the simulators developed using SHULE with Moodle, is a new activity called "game". This activity will allow the competition among students by publicly publishing the results obtained. The integration should define a bidirectional information channel between the learning platform and the simulator. By using this channel it should be possible to instantiate simulations from the LMS, so teachers do not need to create activities in two different environments. In addition, teachers will be able to gather information about what is happening in the simulator and use it in the context of a game. For the students this can be helpful because what they carry out in the simulator will be taken into account. The definition of this communication channel is not easy. It requires to integrate different components and to define clearly the information to be exchanged.

Regarding how the integration of the simulator and the LMS works, it is necessary to take into account that the Simulator has two main components: the simulator core (HLogic) and the game engine (HBOgre). Like if it was a video game, the simulator uses the game engine to represent the simulation activities controlled by the core. However, what happens in the simulator should be reflected in a virtual place (i.e. LMS) so that players can compare their results with others. In addition, the virtual place would allow the publication of such information, which can be used in educational or professional contexts. In SHULE's case, the idea is the representation of the information in the institutional LMS. In order to address this problem, LMS web services are used.

Moodle includes a scalable web service layer that can be modified in order to include new functionalities in the learning platform [52–54]. By using web services, both the LMS and the simulator are technologically independent, which means that they can be implemented in different programming languages, use different resources and evolve separately [55–56].

Other issue related to the integration of these systems is how to manage user authentication. The university provides a Single Sign On system. The simulator will be included in that system so that HLogic logging will be provided by this system. This way, the user's credentials will be valid for all the applications of the ecosystem, which includes the LMS.

With regard to the information to exchange between Moodle and the Simulator, as already mentioned, we have followed two of Malone categories classification to define what to exchange and from/to what component: challenge and curiosity. The third category, fantasy, is ignored because it does not suit one of the goals of the Simulator, that is, achieve a certain level of realism. Taking this into account, the information will include:

- From Moodle to the simulator:
  - Information about the user that defines the activity: The teacher can create activities into Moodle that are linked to the simulator.
  - Specific information about the activity to carry out: The teacher can set up the activity inside Moodle, with the features desired for difficulty and level of expertise that is later shown to the student in the simulator.
- From the simulator to Moodle:

– Information about the final grade of each step for the users. With this information the teacher can know which part of the activities is harder for the students.
– Information about the simulation sessions: Outcomes like time employed, tools used or number of errors, and the description of those errors, so the teacher can know what are the most common problems found. An also data for measuring the effort like number of times the simulation has been executed, total time employed to complete a level, etc.

With the information obtained from the simulator, the LMS can automatically associate badges [57] to the student depending on the results. They are a way of celebrating achievement and showing progress that is a way to show when a user completes a set of tasks or achieves a set of competences. When users pass a simulation with a grade and in an acceptable time (fixed by the expert/teacher) they will obtain a course badge. These badges are compatible with Mozilla Open Badges [58] and therefore exportable to other contexts.

Figure 1 shows the whole process for a user session to take place. The information starts to move when the teacher logs into the university LMS by using the Single Sign On System (arrow labeled with the number 1). Once logged, the teacher creates a new activity inside a specific course so students can later have access to it, represented in the figure as the arrow labeled with the number 2. This activity contains all the information to define a new game instance inside the simulator. Such information corresponds to the configuration parameters of a simulator's game instance, and contains all the elements defined previously in Malone's challenge category: information about the user, the description of each step, the steps' scorings, the skill level requirements, etc. An example of this kind of activity could be a "cataract surgery by phacoemulsification". Inside it, one possible configuration of the activity could include 10 different scenarios for the simulator, each ranked with a difficulty level: beginner, intermediate and advanced. The configuration also includes that to complete the activity, the student must successfully complete at least two scenarios of each level with at least a performance of 50%.

Once the game configuration is ready inside the University LMS, the next step comes when a student logs into the system (arrow 3). Inside the LMS, the user should see that there are activities available to perform. By selecting one, a new instance of the simulator will be created using the data provided by the LMS. This data will be loaded into the Simulator (using both HLogic and HBOgre) and the student will just need to "play" the game (arrow 4) in order to use it. While "playing", the Simulator tracks the student's performance through the haptic feedback so such information can be later transferred into the LMS. When the student has finished

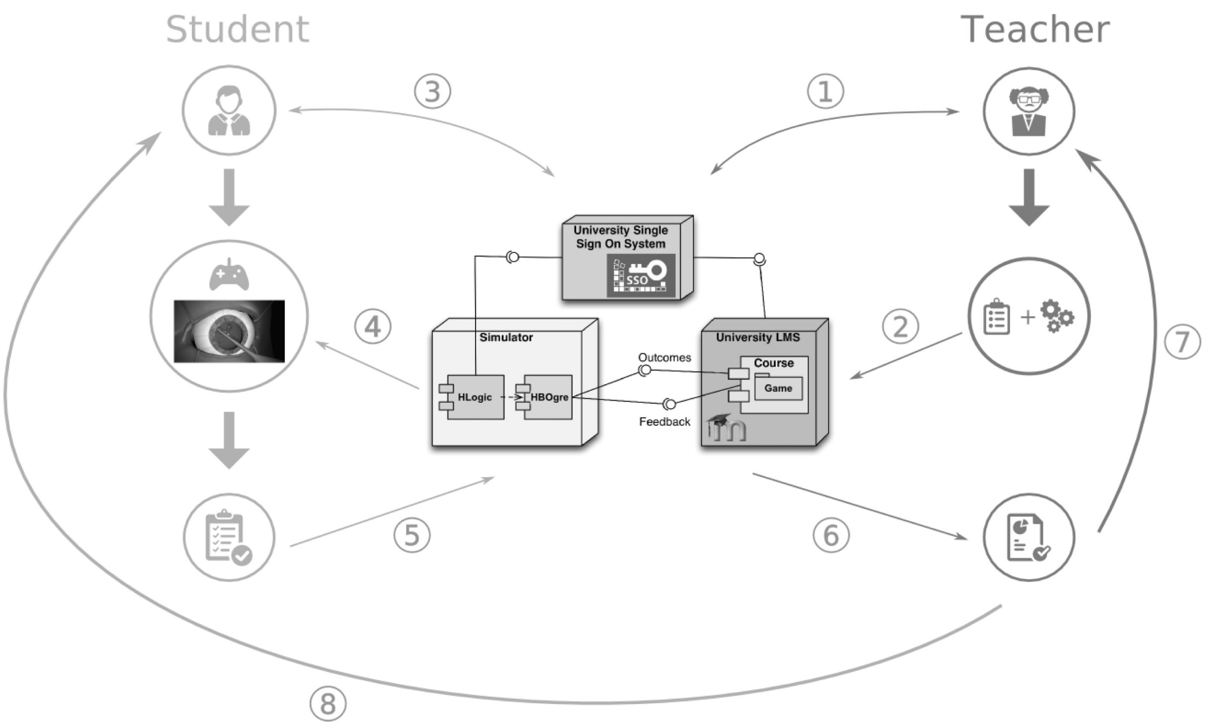

Fig. 1. Integration of SHULE and Moodle: information flow between the users and the framework.

the game session, the Simulator collects all the performance information (arrow 5) so it can be sent back to the LMS. This information will be transferred as both, feedback for the student and outcome for the teacher. With this, the LMS will be able to generate reports from the student's performance (arrow 6). Finally, these reports are available for the teacher (arrow 7) and for the student (arrow 8).

5. Conclusions

Gamification is nowadays a very popular trend that opens new possibilities in eLearning contexts. One of these contexts is engineering education. In engineering education it is very important to provide students and teachers with tools that help them to experiment and obtain expertise by interacting with the environment they are going to find in their future working life, that is, to practice with real environments. This is something usually expensive and that requires of the presence of the expert, which makes difficult that a students can practice as much as they would like. It is necessary to find ways to help students to carry out this kind of activities in a simple and cheap way, and also to look for ways that increase their motivation and enhance their participation. Games and simulators can do this.

In order to do so this paper has presented SHULE, a framework for building virtual reality haptic simulators with which the students can touch and interact with objects difficult to obtain and manipulate. The framework makes possible the development of different simulators that can be applied to different environments in all fields of education such as civil engineering education (to interact with infrastructure), electronic engineering education (to interact with critical devices), surgery (to interact with organs or tissues), etc.

It is very important to motivate students to use these environments so they can be enriched with expert's feedback. In order to do so, the use of the simulators can be instantiated as a game. This game will provide them information about what they are doing right or wrong, their level, allow them to compare their grades with their pairs, etc. To make this possible and to take into account the game outcomes in students' grades, it was necessary to define communication ways between the LMS and the simulators. The simulator would send to the LMS the results obtained by students. This information can be used for generating a scoreboard that would help to consider the use of the simulator as a serious game. This can be the way to obtain a better response from the students, that is, that they practice more and more hours on the haptic simulator to acquire the skills needed.

However, SHULE is still during the preparation phase, so the evaluation and validation of the framework must be left as future work. Also it would be desirable to test the system in different fields of engineering education comparing the results obtained with the ones of traditional education.

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