Supporting Mixed-mode Role-Play Activities in a Virtual Environment

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***Abstract*—This paper introduces an approach to harness the advantages of 3D virtual environments in a more effective way in order to benefit the student's learning in understanding abstract concepts. It is a proposal for a generalized framework that generates a mixed-simulation role-play activity. In this activity, the student functions as a part of a working system in a virtual environment in order to complete different tasks. This framework acts as a template that can be used to design different role-play activities for diverse subjects.**

Keywords-component; Virtual Reality; Role-Play; Immersive Learning; Virtual Environment; Mix-Simulation

I. INTRODUCTION

Even though science educators rely on well-prepared lecturing to present the information, many of them notice that it is not enough. It is difficult for the students to understand the abstract concepts explained to them in a traditional lecture due to the limitation of their minds in visualising and imagining the abstraction of these concepts. After a while, students become unattached and lose their concentration. There is a need to make the class more interactive by using the active learning methods [1]. Role-Play, which is a form of simulation, is one of the techniques used to convey the idea and overcome the difficulty of imagining how to relate these concepts to the real world. The participants interact according to their roles in a structural sequence in order to solve a task collaboratively. It helps the students to explore the subject from several points of view and interact from the first-person perspective. In addition, role-play (or drama) is a participatory method that has been used in teaching computer science. McGuffee [1] is a computer science educator who uses role-play in his classes of teaching the Reliable Data Transfer protocols. Biddle & Noble [2] used CRC cards (which are index cards for distinguishing the roles in learning object oriented techniques [3]) with the role-play for object oriented development, specifically in describing the interaction between the user and the system.

There are many attempts to digitalize and transfer role-play into virtual world environments. Many studies have aimed to prove the advantages of this approach. For example, Sue Gregory & Yvonne Masters [4] conducted a role-play activity using the SecondLife platform based on the "Six Thinking Hats" framework, which aimed to investigate how traditional teaching could be enhanced through the use of virtual worlds. Another study by Cho and others [5] investigated the influence of several factors such as the age and the gender of the users on their physical and social presence, and how this might affect their achievement in a virtual role-play. Mary Dracup [6] in her thesis makes a number of recommendations for the use of role-play after studying its impact on the students' engagement and the development of stories (scenarios) based on their learning tasks.

Scientists from the University of St Andrews introduced a mechanism in order to develop a platform in virtual worlds which showcases the programming power of these worlds and how it can be directed towards the educational aspects [7]. They mentioned how the programmability factor of the virtual world gives it the power of handling any modification or extension of this world. Moreover, it provides the users the control of the environment and the interaction between them within this environment over the simulation.

On the other hand, as many studies claim that the use of computer simulation helps the students to understand complex ideas, the implementation of simulations with numerous unnecessary details will overwhelm and confuse the students [8]. One of the major problems in the creation of virtual learning environments is finding the simplest way to model and represent the abstract concepts into 3D objects, as well as implementing the interaction of the students with each other, their instructor, and the represented objects.

With respect to what was discussed above, in this paper a novel computational pedagogical framework is proposed that creates a role-play learning activity imitating a message-passing system which merges machine simulation with human interaction in a Role-Play Virtual Environment (RPVE), called the Mixed-mode Role-Play (MMRP) Framework. This framework is proposed to explore the learning affordance of humanizing a technical object in simulated system in RPVE. Practically addressing the following:

- To validate the proposed framework as a means of modelling generalizable approach for mix simulation technical-human learning environment.
- To validate the model in a customizing virtual learning environment based on a specifically designed task.

The result of validating this framework will introduce an approach for constructing object container acts as a general template to generate the OO objects of a role-play scenario i.e. data driven architecture.

II. BACKGROUNG & RELATED WORK

A. Role-play in virtual environments

A simulation model, based on established metrics, is used to experiment with new ideas or different situations to come up as the best solution. The Role-Play simulation is used as an exercise in many areas. Andrianoff & Levine introduce three role-play exercises to explain the concepts of oriented design

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[9]. The exercises contain scripts that need to be played by the students with simple real human actions and reference these actions to concepts or methods of object oriented programming. Several teachers reported positive feedback after testing these exercises in their classes in order to prove the effectiveness of this pedagogical technique. One of the most common comments was "It really humanizes the programming".

There have been many attempts to digitalize and transfer role-play into virtual world environments. +Spaces [10] is a framework developed for politics topics and the public opinion towards these topics by using virtual world communities. The researchers achieved to "implement a role-play simulation in 2D and 3D environments based on a structured template and a sequence of activities that are facilitated by an online moderator". Joshi's work [11] focused on the field of education and learning design in virtual worlds. Due to the difficulty of authoring learning tasks in the 3D virtual world, he proposed a mechanism of authoring the learning activities in a 2D learning management system such as LAMS; he then imported and deployed the output file into a 3D virtual platform, which is Open Wonderland.

All of the above studies have proved that role-play in virtual environments is a powerful tool that supports student learning.

B. CRC Cards

The use of CRC cards (Class-Responsibility-Collaborator) is an approach introduced by Beck & Cunningham [3] for the teaching of the concept of objects and pre-existing complicated design to programmers. It is basically characterizing the objects according to their class name, responsibilities, and collaborators, which allows the learners to explore the objects in direct view (Figure 1). The class represents an object that can be anything, such as a person, a thing, an event, or a concept. It has to be defined with a single purpose which can be described briefly and clearly [12]. A responsibility is either a piece of knowledge or a service that the object provides to other objects. The collaborators help in acquiring a particular responsibility by describing the objects that will provide that help.

The CRC card approach is a powerful tool that provides a role-play model. It brings object oriented interactions into life. Each student plays an object in a scenario of system usage. The students fulfil a request or a task by acting out according to the written responsibilities on the CRC card. An object (student) might call for the help of another object (collaborator). The participants interact according to their roles by following their responsibilities. This approach helps them to become more engaged and motivated to learn and understand the process.

Gray and her colleagues [7] extended the use of CRC cards by allowing the students to develop scenarios that identified a desired program behaviour and associated it directly to their responsibilities and the responsibilities of the collaborators, with the use of the Ectropic Collaborative Design Environment, ECoDE.

III. MIXED-MODE ROLE-PLAY (MMRP) MODEL

In this paper, we are proposing a novel pedagogical framework which is designed to generate a role-play activity in a virtual environment, where a mix-simulation will take place between automated objects and a human subject, who emulates the functionality of an object as a part of the system. This framework utilize the clarity that CRC card provides to describe the role and the sense of presence of the virtual environment in generating the role-play activity. Moreover, distinguished computational techniques will be used in order to simplify the creation of a role-play activity that integrates a human interaction into a virtual world simulation.

In a role-play scenario, some of the roles are artificially provided by the system (automated roles) while others are humanized (achieved by students). The roles are populated in the virtual environment as the objects interact with each other by passing massages. These objects are designed with the use of CRC cards. A class object container is used to generate the Object-Oriented (OO) objects instantly with each role-play activity. In other words, different objects appear for different scenarios. In addition, the object container will support the generalization of the orientation behind this framework in a data driven architecture. The use of immersive technologies such as the 3D virtual environment, learning design, teaching strategies (role-play), and the emulation of structuring collaborative learning activities can support the Learning-by-Doing theory and the benefits of such a model over the traditional teaching techniques.

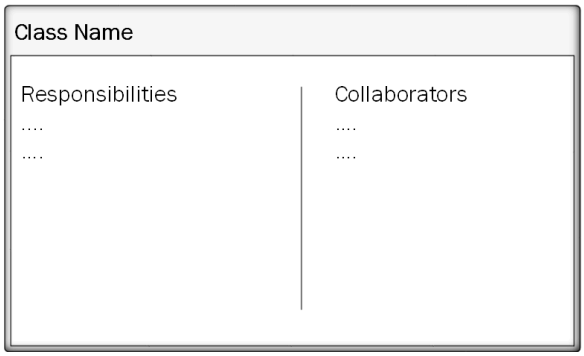

Figure 1: CRC card format.

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IV. LEARNING SCENARIO

A. *Authoring phase*

Initially, in order to apply Mayes & Fowler's pedagogical cycle [13], the student should be introduced to the topic and the concepts earlier through classroom lectures. The instructor sets the learning objectives, and the learning outcomes.

On the instructor interface of the model, an authorized management tool proposes several scenarios for a functioning system to serve their learning objectives. After choosing the scenario, a catalogue of object names that are employed in the scenario is displayed on the screen. The instructor will choose the object that the student will represent in the system. The objects are defined as CRC cards with their responsibilities and collaborators. The scenario will then be mapped, deployed and played by the students in a role-play virtual environment (RPVE).

B. *Play phase*

The student logs into the system in order to play his/her part in the role-play scenario. He/she visualizes the working operating system in the virtual environment automaticity until it stops. That indicates it is his/ her turn (role). The student will play the required part of the object that he/she is representing. The system will resume its work if the student achieves the object work properly. Otherwise, he/she will continue trying or choose to quit. There is a chat server available which is enabling the student to discuss his/her role.

C. *Assessment phase*

The student's achievement and assessment is evaluated by the time and the number of attempts to accomplish his/her task. The instructor also has the option to monitor the student's performance and progress continuously, in order to assist them and give them feedback. The student's progress and achievement is recorded in the user repository within his/her profile.

V. CONCEPTUAL MODEL

The MMRP conceptual framework (Figure2) is divided into four layers and is a joint between the human interactions and the functionality of the machine. Each part depends on the other's functionality. The human is either the instructor or the student.

The layers of the MMRP are:

- ***Task Design Layer***: This layer is responsible for the design of the learning task. The instructor represents the human actions in this layer. Firstly, in the human part of the layer, the instructor sets a desired learning objective that he/she wants the student to learn via a role-play task (such as the learning objective: the process of retrieving a webpage from a server). In the system part of this layer: there are several suggested role-play scenarios that are stored and retrieved from the Subject Database in the Data Layer. The instructor selects a suitable role-play scenario according to the learning objective. The system then displays a catalogue of the role-play objects that are elements of the selected scenario. From these objects, the instructor chooses the humanized object, which will be simulated and functioned by the student (the student achieves the object task).
- ***Objects Layer***: It is the most important layer of the conceptual framework where the core method for adapting the framework to any subject is presented (Using an Object Container). After the humanized object is selected by the instructor, the system begins to generate the OO objects, with the use of an object container. The object container is a structural class which creates unified objects that can perform operations within the object container without an object scope. The object container in this framework is structured as a CRC card (Figure 3).

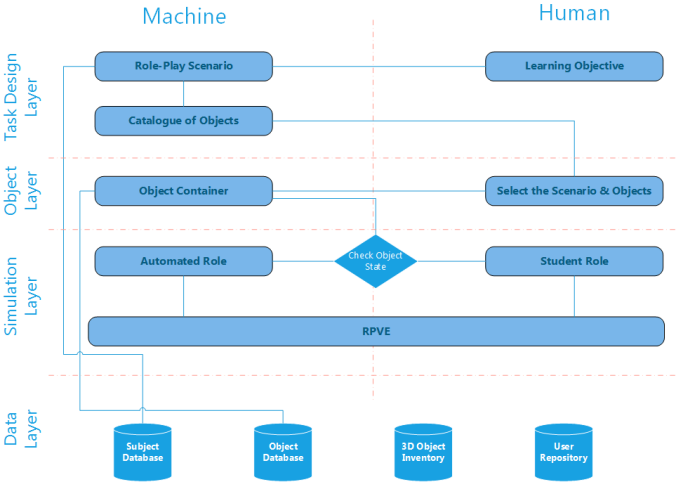

Figure 2: MMRP conceptual framework.

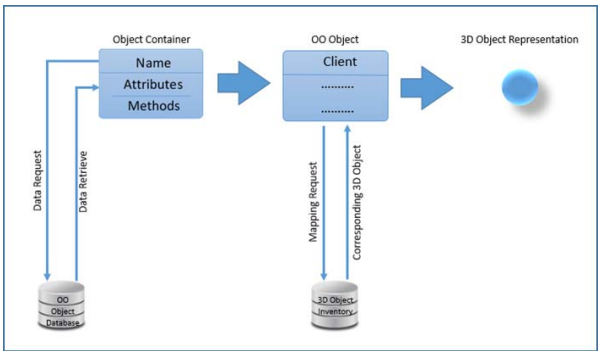

Figure 3: The process of creating the objects.

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Each object can be switched into one of the following two states: ON and OFF.

- *ON State*: It is the default state for any object which indicates that this object will function automatically as part of the simulated system. The required data for constructing each object are uploaded into the object container to create the objects one by one and are loaded to the memory.
- *OFF State*: It means that this object will be humanized (i.e. its function is completed by the student). The required data for constructing the targeted object are uploaded into the object container. In addition, the corresponding object script will be uploaded in order to be achieved by the student.

- ***Simulation Layer***: This is the layer where the mix simulation begins. The generated objects will be rendered and mapped to the RPVE. The student is responsible for the human actions in this layer and will interact with the environment. A behaviour machine will be utilized in order to create the object interaction and their roles. According to the object's script this action will be recorded and tracked for assessment.

- ***Data Layer***: This is the layer of the repository and database where the data can be stored and retrieved. Each subject has its own data and information is provided by its instructor to be stored in the database. MMRP is used in order to link the provided database and generate the desired scenarios, objects, and 3D objects in order to create mix-mode role-play activities played by the registered students.

VI. MMRP System Architecture

The MMRP system architecture (Figure 4) consists of distributed subsystems in order to simplify the implementation process and make it adjustable.

These subsystems are:

- *Instructor GUI:* It is the instructor's interface where he/she chooses the role-play scenario and the humanized objects that will played by the students.
- *Student GUI:* It is the student's interface where he/she enters the virtual environment to play his/ her role in order to achieve the requested task.
- *RPVE Generator:* It is the subsystem where the mix simulation is generated. It contains the object container class which generates the OO objects with their states either set to "ON" or "OFF".
- *Simulator:* It is the subsystem where the mix-simulation will start. It consists of entities that are responsible for controlling the avatars' and objects' movement, and for managing the interaction between the objects.

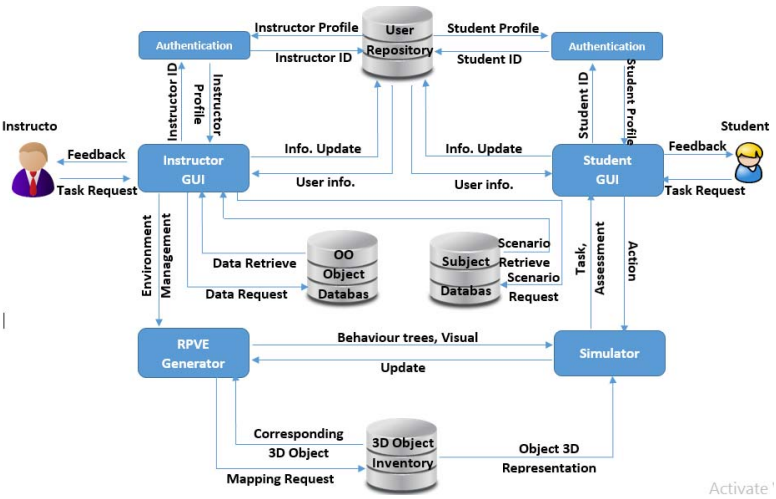

Figure 4: The MMRP system architecture.

VII. Implementation

A prototype model will be implemented based on a Network scenario (Figure 5) in three stages.

These stages are:

A. *Phase 1*: **Design the MMRP to work with one user, a fixed scenario and one humanized object**.

The plan is to design a working Network System in a virtual environment. In this system, there will only be one student representing a fixed object in a fixed scenario. To accomplish this phase the following steps should firstly be implemented:

- Object Container.
- The fixed humanized object.
- The Machine Behaviour.
- The database.
  - The user database.
  - The OO object database.
  - The 3D object inventory.

B. *Phase 2:* **One user with the same scenario with the option to choose the humanized object**

- An Instructor GUI for selecting the object.
- Class State.

C. Phase 3: **Multi-users with the same scenario and each user represents a different object**

- Providing the option of multiple "OFF" objects
- Online server.

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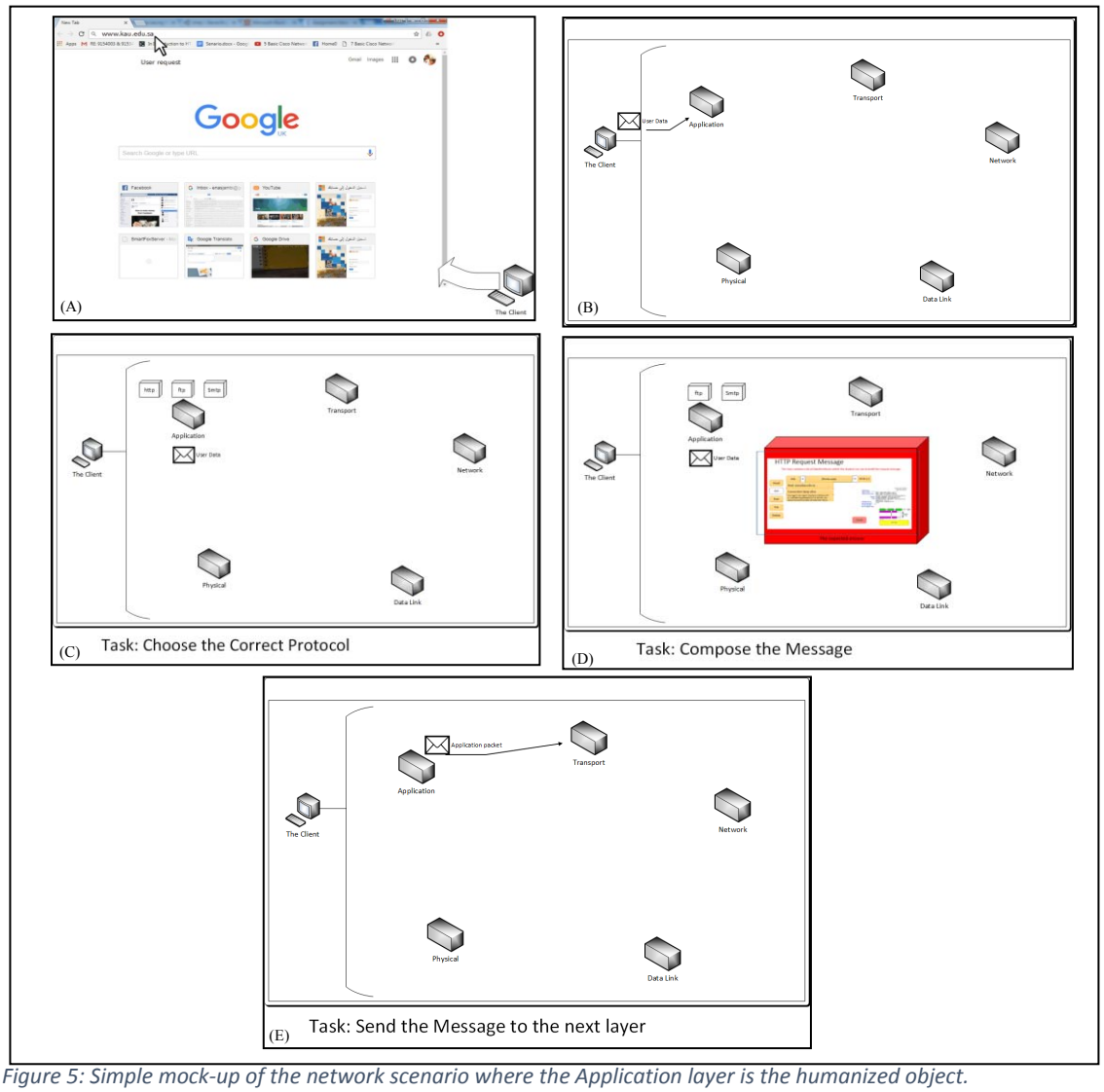

Figure 5: Simple mock-up of the network scenario where the Application layer is the humanized object. The current screen mock-up is based on a 2D format. We are currently developing a first prototype that will investigate how these features can be translated to the 3D environment

VIII. CONCLUSION AND FUTURE WORK

The proposed framework in this paper is an approach to generate a mixed-mode role-play activity, where the students will be immersed in the learning process. The students will become a part of a virtual working system and imitate its behaviour. The fact that the students are trained to function as working processes in a system will help them learn the subject in a visualized way in order to enhance their understanding.

This paper is part of a research project that is in-progress and needs more time in order to be completed. The objectives behind this project are:

- To define model in the fields of Computer Science and Immersive Learning to structure a role-play activity.
- To build a state-of-the- art pedagogical prototype.
- Explore the affordances of using 3D spaces in structuring mixed-simulation role-play activity
- To simplify the simulated environment and the representation of its components
- Evaluate the efficiency of the proposed research model

The future plan is to implement a prototype based on a Network scenario. During the implementation of such a prototype, there are several challenges that are going to be faced. One of the challenges will be the process of finding common features for the generated objects, which the attributes and the methods of the object container will be designed around. The authors are in the stage of investigating these concerns.

This prototype will then be used as the basic (template) model in order to create different role-play activities for other subjects that involve message-passing.

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The MMRP model was based upon the assumption that CRC cards and role-play are more effective teaching approaches, which enhance the students' learning and understanding, than the traditional lecturing approach. For this reason, there exists the intention to evaluate the prototype model through empirical experimental phases which will validate the research model and framework. The same subject will be given to two groups, where one will be a control group and the other will be using the implemented prototype to validate the research claims. These learning approaches will be as follows:

- The control group: The subject will be explained to the students only via a traditional lecture. They will then participate in a face-to-face role-play using CRC cards. After this stage, they will take a test.

- The experimental group: After receiving a lecture about the subject, the students will participate in a role-play activity as a part of a simulated system in the virtual environment (using the MMRP model), and they will then take a test.

A statistical analysis will be carried out on the students' tests in order to evaluate each approach and compare their results. The results and the analysis of the evaluation process are planned to be presented at future conferences.

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