A Competence Performance Analyser Tool for Assessing Players' Activity in Serious Games

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Abstract. Serious Games are recognized as one of the most promising innovative learning technologies in the short-medium term. Even if it is wide recognized the empowerment of learning they provide, there are few means to trace and measure learners' performances during game sessions. This paper describes a Competence Performance Analyser tool that keep trace of the players' activity in the shape of events in game and basing on these ones assesses the related performances respect to a predefined set of competences.

Keywords: performance assessment, seriuos games, e-learning, competences, performance indicators

1 Introduction

Game-based learning has grown in recent years as research continues to demonstrate its effectiveness for learning for students of all ages. The greatest potential of games for learning lies in their ability to foster collaboration, problem-solving, and procedural thinking. For a variety of reasons, the realization of this potential is still two to three years away [1].
In the context of the European project TARGET [2], gaming is deemed significant as a conceptual practice with outcomes that enable students to gain skills needed specifically in an information-based culture: a serious game is used to provide work-like learning experiences. The present paper depicts how players' performances are assessed in relation to a set of competences, basing on their observable behaviours in game.

2 The Theory

In the following we outline the background theoretical modelling of game scenarios, competences and performance indicators until the performance assessment model.

2.1 TARGET Scenarios

The project supports three scenarios, all of them dealing with project management. The rationale behind is that after studying on manuals and courses a novel project manager can benefit of experiencing different strategies and behaviours in a safe (consequences-free) environment, such as the serious game one, to approach and face work-life problems, to develop soft skills such as negotiation, trust building, communication. For example, one scenario deals with the need of building a road on a certain land and convincing the owner to sell. Another scenario is about the ability to carry on the products' lifecycle assessment. Last scenario presents the challenges of team recruitment and the player acts as a "Social Architect".
These scenarios are playable stories into a 3D serious game environment, based on Unity 3D[1]. Into a realistic context the player can experiment alternative strategies to face every day working problems and challenges, moving across offices and job settings, interacting with colleagues, customers and stakeholders' avatars. The Game platform was extended in such a way to send information (as background, not intrusive events) about specific player's actions and behaviours to the assessment module.

2.2 From Scenarios to Competences and Performance Indicators

A review of the literature, especially about competence modelling for TEL, provided a deeper understanding of the individual competences and the abilities of a person who has the competences; however, this work did not help identify how this ability is affected in different work contexts. This led to the formulation of the OKEI Competence Modelling Framework [3] [4], which identifies different factors of a competence that distinguishes a person's ability to do something, his/her knowledge about something as well as how the ability is exercised by applying the knowledge in a specific context such as within a specific organisation.

The OKEI factors are four:

- Organisation: the organizational aspects that influence the work performance and the application of competences, i.e. strategies, values and goals of the organization, work processes, organization structure, roles of people within the organization, the competence profile that one is expected to have is mostly determined by the organization.
- Knowledge: the external knowledge resources that could be useful to apply or exercise in the work task at hand, i.e. academic, theoretical or practical knowledge resources.

[1] http://unity3d.com/

- Environment: the context outside of the organization, i.e. other companies and industries, networks, public sector and governance, the laws and norms, existing technologies and infrastructure, the market and culture, not to mention the people as consumers, users and citizens.
- Individual: individual and personal factors that may be applied in work situations and that have varying connections to one's performance level, such as knowledge, skills, past experiences, personality traits, mental models, attitudes, motivation, intentions, perceptions and emotions that can either be utilized in work tasks or they influence it in some way.

The OKEI Competence Modelling Framework facilitates the description of competences to the level of detail where elements of the competence can be linked to observable behaviour of people that are able to apply that competence (or reversely, the lack of an ability to apply a competence). Three of the four OKEI Competence Modelling Framework factors, namely the organizational, the knowledge-related and the environmental factors define the "context" in which the competence may be applied. The remaining individual factor describes the competence itself in more detail. Thus, it leads to a specification of the competence and/or to the definition of related sub-competences. Based on specific competences or on more specific sub-competences, it is possible to identify behavioural indicators.
The behavioural indicators, in turn, can be used to derive performance indicators for the learners, which can be used in the formative evaluations of the learners [5]. A performance indicator is a concrete instantiation of a behavioural indicator tailored to the TARGET game to be used to facilitate competence development. The more contextual factors, i.e. mediating variables, are taken into account, and the more possible values for each variable, the more complex the process of operationalization becomes, leading to a formula such as a multiple regression equation.

As an example, the communication competence is calculated basing on trust building, non-verbal and verbal communication sub-competences. Non verbal communication is calculated using the"proxemics" performance indicator. Personal space (or proxemics) [6] can be defined as the area individuals maintain around themselves into which others cannot intrude without arousing discomfort. Which (range of) physical distance between two persons can be seen as appropriate, i.e. which distance doesn`t arouse discomfort or stress, is mediated by a great amount of contextual factors, such as cultural background of the other(s), status differences, amount of people, overall available space, etc...
So the appropriate physical distance d_{appr} can be calculated with the following multiple regression formula:

$$d_{appr.} = d_{contact} + x_{c\_b} (d_{noncontact} - d_{contact}) + x_n * d_{contact} + x_{sd} * d_{std}$$

with the parameters:

x_{c_b} = 1 : if the NPC has a noncontact cultural background
0 : if the NPC has a contact cultural background

x_n = 0 : if $n \leq 4$ (= Personal Space)
5 : if $n > 4$ and $n \leq 8$ (= Social Space)
13 : if $n > 8$ (= Public Space)

x_{sd} = 1 : if the status of the NPC is higher than the status of the avatar
0 : if the status of the NPC is equal or lower than the status of the avatar

This short introduction to the OKEI model was meant to provide just an overview of the theoretical basis of the CPA module and of course didn't mean and neither could be exhaustive. For further information please refer to the related documentation, as from [3], [4], [5].

3 The Implementation

In this section we describe how the previous concepts have led to the implementation of a Competence Performance Analyser software module.

3.1 Tracing Player's Performance

While the learner plays, the Game traces his/her behaviour and provides data to a dedicated software module called Competence Performance Analyser (CPA) that elaborates the information and assesses the performance. This means that specific actions of the player are recorded, for example movements into the 3D environment, expression of emotions and text written in chat. These raw data are used by the CPA to calculate performance indicators and in turn, grounding on these ones, to assess performances respect to competences. Which actions have to be monitored and how to combine them to assess the performance was elaborated via the methodology described by the previous section.

3.2 Competence Performance Assessment

The Competence Performance Analyser module implements the assessment of the player's performance as from previously discussed theoretical basis: competences are assessed as a weighted sum of certain performance indicators, that are calculated basing on player's actions in Game.

The CPA module is made up via a number of internal components, as from Fig. 1.

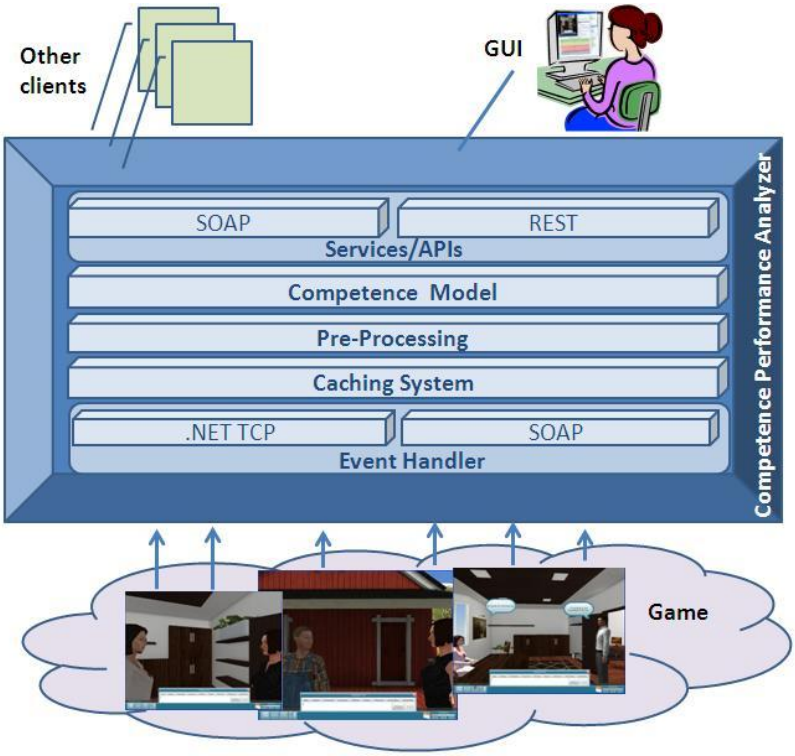

Fig. 1. CPA Architecture

The results of the CPA calculations are presented to the user in a graphical, intutive manner af from the CPA GUI, that is the higher level in Fig. 1 and is presented in Fig. 2.

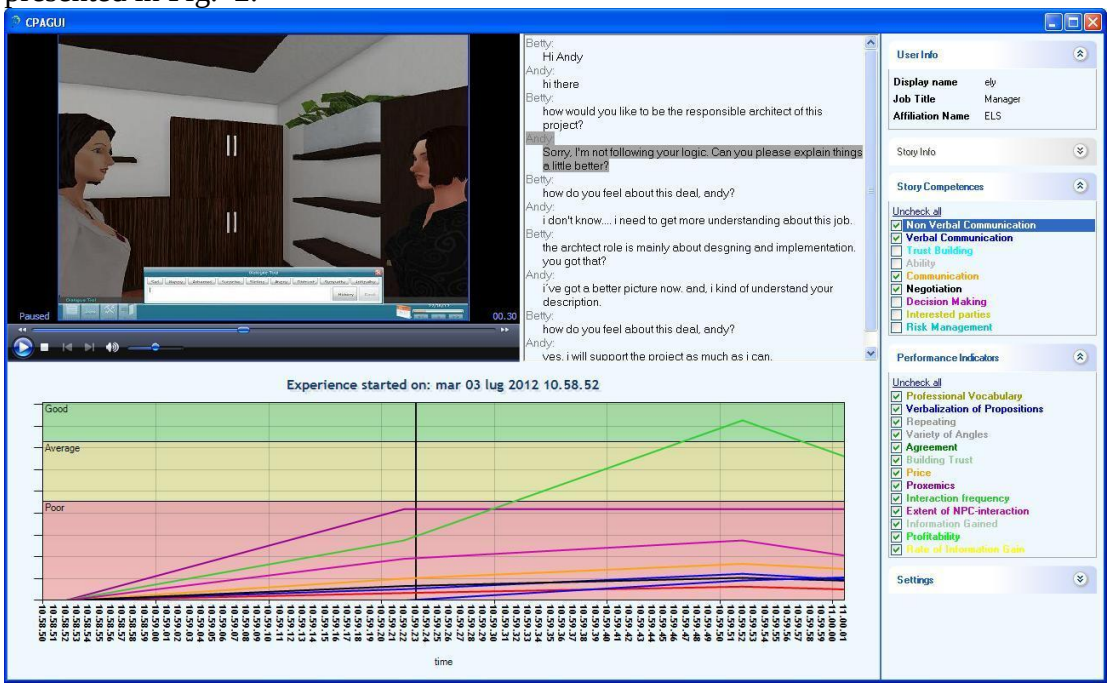

Fig. 2. CPA GUI

The CPA GUI is the interface between the computing back-end software and the human end user. The GUI has to present information in such a way to provide an effective reflection means, where it is straightforward to understand which action/sentence led to a specific assessment and why. So the GUI has three distinct areas:

- Experience Replay (top left), where the user can play-back his game session. The play button functions both as play and pause button and by clicking on a particular point of the progress bar it makes the play-back go to that point. As with this kind of visualization it can be a bit hard to read the chat lines, the text is displayed on the right of the video area and sentences are highlighted synchronously with the replay.
- Performance Graph (bottom), showing how the player‘s performance evolved along the time for each competence and performance indicator involved in the game scenario. Competences and Performance indicators can be selected and unselected as needed/wished form the lists on the right side.
- User and story information (top right) , with a few data about the "owner" of the experience, such as username and job title. In this way a minimal background about the player is provided (with job title), thus respecting his privacy (with anonymization with username), avoiding a specific identification, but still allowing, for example, browsing his learning path, i.e. by looking for his game experiences, comments and annotations. A synthetic description of the story is provided too.

This kind of visualization was meant to support reflection upon the learning game experience. The replay of the experience presents a video to show what the user was doing at a spsecific moment into the Game, a hightlight of the chat, to show what the user was saying, and a graph showing the assessment of competences and performance indicators, with a bar moving throught this graph synchronously with the progress of the other data. The early version of the interface had a quite different layout, the current display mode was re-arranged after an evaluation cycle to grant better usability and effectiveness of the provided information.

Behind the scenes, SOAP and REST APIs grant access to the CPA methods via programming interfaces. Calculations run into the back end thanks to:

- Competence Model (CM) and Pre-Processing modules, responsible for collecting pre-processed data and calculating discrete values for performance indicators and competences. The competence model for a given competence contains all information about the performance indicators used and the formula to assess the performance and trend for the competence and the performance indicator. The Pre-Processing component elaborates raw data and makes them homogeneous. This is needed because raw data arrive at different rates and times: the Pre-Processing component is aimed to interpolate missing data, if possible, and to send back to the competence model comparable data. To complete the process all the data are used to calculate the performance, applying the formula from the competence model Game Status Connector. This process is depicted by Fig. 3.

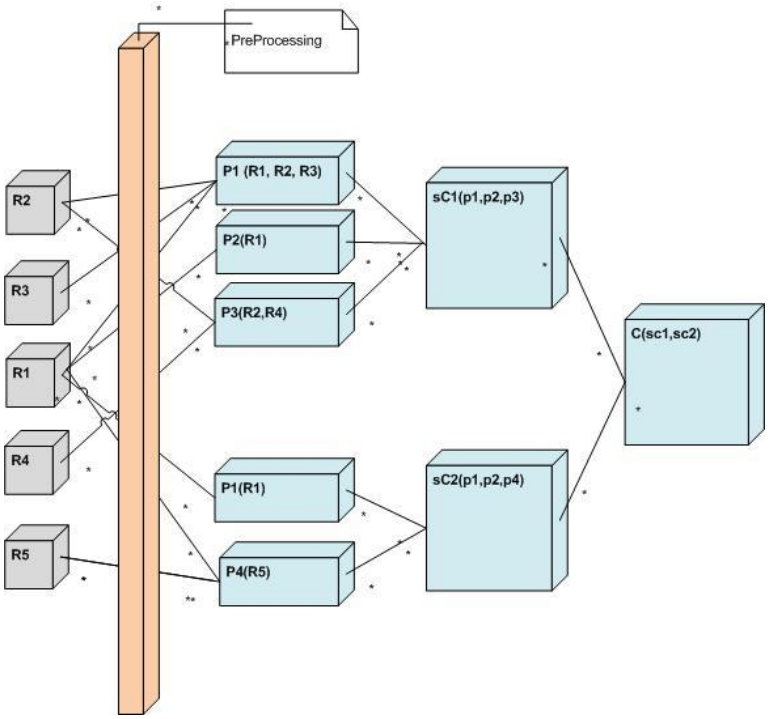

Fig. 3. Data Elaboration inside the CPA.

From Fig. 3 it is possible to understand better how the competence model works. The raw data (R1..Rn) are pre-processed. A function Px(Rk,… ,Ry) is applied to these values over the time and the resulting value of the function represents the Performance indicator value at a fixed time. sCx is a sub competence. A sub competence is itself a competence. The performance related to a competence is calculated as a combination of Px formula or combination of sub competence formula. When the data are ready an array of pair <time, value> in the requested period of time is returned to the above component.

- A Caching module, for a faster access to data.
- Event-Handler modules receive and dispatch events from Game. As the Game needs to send a large amount of data (i.e. performance indicator related data, game status, etc..) a .NET WCF RPC based event handler provides a good integration means but it could create integration problems with other components that are not .NET based. For this reason, a second event handler is provided, exposing its interface through a more classical web services based on SOAP protocol.

Data about player's performance can so be accessed in two ways:

- in a graphical manner, via the CPA GUI, showing information and assessment about a specific experience, that is re-proposed in real time
- at service level, via REST and SOAP web services, data can be requested at different levels of granularity. This allows further elaborations, comparisons and evaluations.

4 Conclusion and Further Work

We have presented here the Competence Performance Analyser module developed within the TARGET project. We have presented both the theorethical

basis as well as the implementation criteria and outcomes. The project is now at its final phase. As explained before, early evaluations cycles were already run and gave a good feedback about the CPA module; more evaluations are running at the time of writing, so we can't report more users' feedback.

We think that some ideas at the basics of our work can be further elaborated and/or reused:

- the criteria for usability and effectiveness of the GUI for supporting reflection could be further elaborated and researched
- the basic idea of calculating assessment for competences and performance indicators can be reused and the code can be properly updated to get raw data from different events in different contexts and settings (i.e. data about the user's interaction with online courses instead of serious games, like SCORM tracking ones)
- social aspects could be added, as the possibility for community users of annotating, tagging and commenting specific parts of the experience
- with further extensions, the tool could become configurable enough to allow an average, not developer end user (i.e. a trainer) to provide own formulas for performance indicators and competences – while so far this is coded into the back end
- the assessment data could be compared per single user over time and/or per groups of users with common characteristics, researching i.e. learning evolution, common beahviour patterns, etc... supporting learning analytics
- several users' performance data across the game could be compared to detect frequent problems, errors or even the simplest challenges, to be able to re-design and enhance.

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