DEVELOPING A SERIOUS GAME FOR PSS

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ABSTRACT

Purpose: This paper presents the system architecture of a serious game, which is going to be run in parallel to Rolls Royce training on product-service systems (PSS).

Design/methodology/approach: The original game is outlined, requirements for an online version are defined, and the architecture is proposed.

Findings: The games approach has proven its value in design for service training but an online version is needed to improve the opportunities to deliver the game.

Originality/value: Such a system presents opportunities for the acquisition and development of specific professional knowledge, skills, and competencies

Key words: high fidelity, game engines, serious games, game-based learning, education, pedagogy

1. INTRODUCTION

Modern manufacturing is now extending well beyond mere production, and Product-Service Systems (PSS) are key to industrial success. Within a PSS, the manufacturer still produces the equipment and also takes responsibility for its through-life performance. In return they receive payment as the customer uses this 'capability'. This is a 'value in use' business model; the responsibility for equipment performance lies with the manufacturer, who receives revenue as the equipment is used by the customer.

PSSs can have an enormous impact on turnover and environmental sustainability of a manufacturer. Rather than a single transaction for the sale of a product (and then hoping for revenue for spare part sales) long-term value capture increases significantly. As a consequence, turnover can increase dramatically, in some cases by up 30% per year throughout the lifetime of the contract.

The uptake of PSSs across manufacturers in the UK is however slow. Researchers continue to praise the successes of companies such as Rolls-Royce Aerospace, yet wider adoption across supply-chain is limited. In 2009, a national survey of 500 manufacturers revealed:

- Lack of understanding about servitization and PSS with a significant number having difficulty in thinking of new and creative ways to provide a service for their customers.
- Enormous cultural challenges and uncertainty about the impact of servitization and PSS.
- Fear about the risks (short-term & long-term) and unforeseen business scenarios.

A manufacturing transformation will only be achieved if these issues are addressed. Senior managers need to be engaged extensively, their understanding and awareness improved, and their people trained. Embedding the new service culture in a business requires the development of new skills, attitudes and even a "ubiquitous language"(Evans 2003): a service vocabulary shared the entire workforce of an organization. Greater knowledge is required about successful and accelerated pathways for servitization within mainstream manufacturers. Establishing this knowledge is the manufacturing challenge.

Design for service has a critical role in ensuring the economic viability of PSS (Harrison 2006). For PSS business models to be successful, Original Equipment Manufacturers (OEMs) need to develop products which are more efficient and reliable, as well as easier to service. With the shift of responsibility for after care back to the OEM, designing for low production cost is no longer the best

long-term strategy. Long-term profitability of PSS is grounded instead on whole life cost of the product, including servicing and spares. This is a prime example of an attitude that needs to be changed in a company for PSS to provide a successful business model.

It has been shown that serious games benefit business decision making by engaging and motivating the workforce, improving training outcomes, and influencing the behavior of their existing and potential customers (Donovan 2012). However the effectiveness of the serious games could be influenced by a number of risk factors such as the rate of change of ICT Technologies and the ongoing efforts in order to support the infrastructure, losing the balance between pedagogy and gaming, the change in nature of gamers (Petridis et al. 2015).

Rolls-Royce has a pre-existing game which is used to teach key concepts of design for service in face to face sessions. The current game has been used extensively in Rolls-Royce to provide training across all areas of the company, including managers, engineers, sales staff, and many other personnel, in support of its Rolls-Royce TotalCareTM programme. The game is credited within the company with bringing the learning in the Design for Service course to life. Over the course of a couple of hours the language used by the participants visibly shifts and directly supports the cultural shift demanded by a PSS rather than manufacturing focus. However, the face-to-face nature of the existing game limits the opportunities for delivery to scheduled training sessions led by specialist facilitators. It cannot, for example be offered on an as-required basis to new members of staff, nor indeed online to university students, nor in the context of a Multiuser Open Online Course (MOOC). The Design for Service game thus offers an opportunity to take a game, for which the game mechanics are tried and tested, and explore how porting it to digital, in the form of a serious game which can be delivered as a self-contained virtual learning environment, affects how it can be delivered, and learning outcomes for players. To do this the first step is to design the architecture, which is the main contribution of this paper.

The rest of this paper is organised as follows: Section 2 describes related work, providing a review of the current state of serious games for training. Section 3 presents the first version of the Design for Service game as originally developed by Rolls Royce. Section V represents the architecture of the second version of the game which is a digital version of the first version of the game. The final section represents the conclusions and future work.

2. BACKGROUND

Modern businesses are faced with new challenges due to the rapidly evolving marketplace, to the shifting labour markets. Addressing these challenges requires a wide range of skills from both senior and front-line staff, in-turn requiring innovative and effective training tools such as serious games, gamification applications to aid staff at all levels of an organisation as they adapt in response to emerging challenges, game based learning provide opportunities for various organizational need such accelerating learning (Laine 2012), driving workforce productivity (Cook 2013), communicating with customers ((Werbach 2013)(Werbach & Hunter 2012)) and collaborating with business partners (Hugos 2012).

Because of their ability to motivate, engage and influence behaviors, serious games are being used in the corporate sector for training, recruitment and marketing and sales, via targeting planning, problem solving and hypothesis verification ((Donovan 2012)(Petridis et al. 2015)). However in order to improve the uptake and the evaluation of serious game, it is necessary for the designers to support higher order thinking (i.e. strategic thinking, analysis and interpretation of events,) and creativity simulation. This can be achieved through advances in Artificial Intelligence (AI), in particular concerning the simulation of (single) human behavior, in order to allow creation of living worlds, populated with realistic, or at least credible, non-player characters (NPCs) (GALA).

Large organisations are investing resources in using games to train their workforces in areas ranging from compliance training to leadership development. Serious games provide employees with a compelling context-relevant storyline, achievable goals, constant feedback on their progress and rewards such as achievement badges and public recognition. They also provide employees with opportunities to fail, learn from their mistakes and try again in safe environments. Typical examples games used for corporate training are IBM's CityOne, Siemens Plantville, CoCo Sim ((Donovan 2012)(Petridis et al. 2015)).

However, several factors inhibit the uptake of serious games within business. One such is the traditional high cost of game development compared to learning approaches (Petridis et al 2015). Another inhibiting factor lies in organizational cultures in which buy-in can be difficult. This difficulty underscores the often-cited need for development effort to be genuinely collaborative in nature, in order to balance the needs of engagement with the needs of instructional design. The research in this paper presents a snapshot of such a collaborative design process in action (Petridis et al. 2015).

3. FIRST VERSION OF THE GAME

The first version of the game was created by Rolls-Royce in 2001 and was played around 15 times in the first year by around 15-20 people each time. It provides training in design for service to engineers, managers and other employees. It has since been run 2-3 times per year within the company as a 3 hour training session, as well as on an MSc programme at Cranfield University. Within the context of Rolls-Royce the game is credited with bringing the training to life, and with the shared experience of the game giving employees from across the global corporation a shared vocabulary and conceptualization around service design.

The game concerns the design and servicing of washing machines for a customer who runs a chain of laundrettes. Teams each represent competitors in the washing machine market and the aim is to maximise profits. At the end of each round an Excel spreadsheet with an embedded Monte Carlo simulation is used to calculate the performance of the companies, and players are presented with a visual report, which summarises their performance and highlights key areas for improvement using red, amber, green colour coding.

The design for service is played in four rounds:

- Round 1 Players are given a brief introduction to the concepts of design for service and then have to quickly make three design choices using information on cost and reliability provided in a catalogue of parts (Fig.1). Typically, at this point, habit and time pressure will drive players to choose low cost options, a traditional design choice but not one likely to improve the in-service reliability. At the end of this and subsequent rounds players are given feedback on the performance of their company in comparison to other teams in the form of an auto-generated analysts report (Fig. 2).

    - The key learning point of Round 1 is: if you don't understand the requirement, or how you can achieve the requirement you tend to do what is easiest – clear understanding of the requirements is key.

- Round 2 Players are given the opportunity to interview a service engineer (role-played by the game facilitator in the original version). This allows them to gather information about

- which parts of the washing machine breakdown and require the engineer to be called out. They can now remake their design choices taking into account how long components last in service, their cost per year etc.

- The key learning point of round 2 is: a little service information goes a long way to optimising the result.

- Round 3 Only two design choices can be changed in this round. This drives players to be more selective about where they apply time and effort and to focus on the most important KPIs in the end of year report generated in the previous round.
    - The key learning point of round 3 is: service costs are not linear – focusing on the few key drivers gives disproportionate benefit.

- Round 4 Only one design change is permitted in this round, but it is a 'real' design choice, i.e. players are no longer constrained by the component choices presented in the catalogue but can decide to alter their designs in any reasonable way. The facilitator decides if the choices are reasonable and applies a cost and lifetime based on engineering judgement before running the Monte Carlo simulation for a final time.
    - The key learning point of round 4 is: innovation and challenging the historical 'norm' is a major opportunity.

Figure 1: Pages from the catalogue of parts

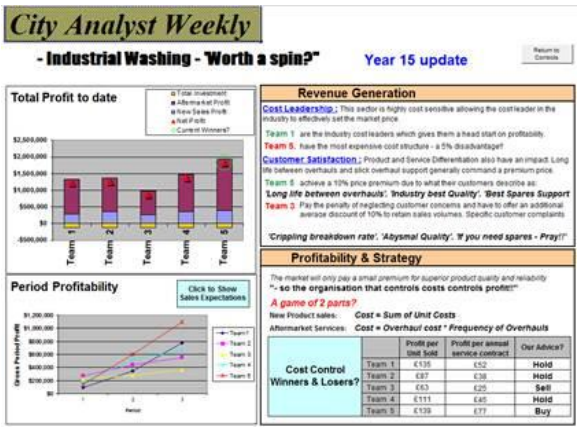

Figure 2: Analyst report provided as end of round feedback on performance

4. SECOND VERSION OF THE GAME

The serious game version of the Design for Service Game is envisaged as an on-demand, online version of the game, which might, for example, be embedded in Massive Open Online Courses (MOOC) or blended learning environments. A further challenge in implementation would be the desire to support both 'group' participation (e.g. teams competing against each other for an MSc online module where the dialog between team members enables peer assisted learning), or individual participation (e.g. players compete vs virtual competitors in machine mode).
To achieve this outcome the following requirements were specified:

1. Taught elements to be embedded within the game environment.
2. Interview with the service engineer to be delivered virtually, e.g. using an avatar.
3. Illusion of competition to be maintained even in a single player game.

The Monte Carlo simulation is to be retained as the game scoring mechanics.

5. PROPOSED SYSTEM ARCHITECTURE

The following section focuses on the proposed system architecture for our Design for Service Game. The system is divided into three parts (Fig. 3): the Logic Layer, the Data Layer, and the Presentation Layer.

5.1 The Logic Layer

The Logic Layer drives the simulation. The simulation consists of a pool of services such as:

- Step manager: provides the next step based on the decision of the player.
- Status manager: is responsible for the interpretation of the next step based on the input provide by the GUI-core.
- Response generator: is responsible for providing the next step based on the input from the step interpreter.
- Simulation: the Monte Carlo simulation takes as input the players'design choices as well as historical choices to create the illusion of competition and calculates company performance measures.

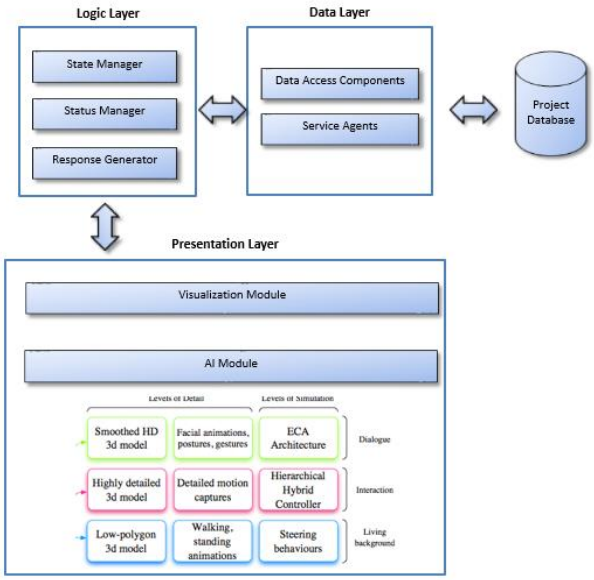

Figure 3: Proposed System Architecture

5.2 The Data Layer

The Data Layer is responsible for accessing the scenarios and data that are stored in the Project Database. The Data layer includes:

- Data Access component: these components are focussing on abstracting the logic, which is required in order to access the data.
- Service Agents: this component is focussing on implementing code to communicate with a particular service such as offline support, caching etc.

5.3 The Presentation Layer

The Presentation Layer is divided into two distinct components:

- The Visualization engine: is based on the Unity3d and is responsible for rendering the game environment. In order to accommodate the different types of data several graphical user interface template are going to be created. Once a step is received from the Logic Layer, the appropriate template will be selected and the rest of the step information will be received and will be injected into the template at which point the template can be displayed to the user.
- The Report engine: generates the colour coded company reports at the end of each round to direct the players' attention towards key areas for improvement.
- The AI component**:** The LoI framework simplifies the interaction between the player and the non player characters (NPCs). Graphically, the LoI can be represented as auras of increasing complexity centered on the players avatar. LoI is based on a simple social space metric [31] and is divided to three levels. The first level aims to populate the characters with authentic crowd in order to increase the immersion of the player. Characters located in closer

surrounding of the player belong to the interaction level. Finally, a character inside the dialogue level interacts with the player in a natural way, ultimately using speech recognition and synthesis. All the NPCs by default belong to the background level, but as the player moves in the environment and they happen to get closer or away from the player and thus enter or exit the interaction or dialogue levels.

6. CONCLUSIONS

This paper presented the system architecture for the digital version of the Rolls-Royce Design for Service. The authors presented their plans for implementation of such a system. The authors believe that such a system presents opportunities for the acquisition and development of specific professional knowledge, skills, and competencies. We expect the application of a game based learning environment will stimulate and engage the trainees.

Future plans for this game will include the comparison of the face-to-face game with the digital counterpart in terms of knowledge acquisition, and engagement.

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ACKNOWLEDGMENTS

This work was supported by EPSRC Grants Ref EP/K014064/1, EP/K014072/1, EP/K014080/1 'Transforming the adoption of Product -Service Systems through innovations in applied gaming technology'; a joint project with Aston Centre for Servitization Research and Practice, Aston Business School and the Advanced Manufacturing Research Centre, University of Sheffield.

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