Learning and Designing with Serious Games: Crowdsourcing for Procurement

Edward Oates(✉)

Centre for Defence Studies, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, SN6 8LA, UK
e.oates@cranfield.ac.uk

Abstract. This study takes a novel approach to defence procurement. Through the use of a Serious Game, developed using Open Source coding techniques and internally Crowdsourced, the design of defence equipment is developed through a wider than usual range of user perspectives. The aim is to reduce procurement cost by exposing defence equipment to a wide range of users ahead of the in-service phase, where re-work becomes more costly. Not previously reviewed the conjoining of a Serious Game, Open Source coding and Crowdsourcing has technical and cultural issues within UK defence. This is an interim report after the first year of work.

1 Introduction

The main themes of: defence procurement, serious games, open source coding and crowdsourcing, interlink in specific ways that require a short introduction. The paper then goes on to describe the study in further detail.

1.1 Defence Procurement Process

The UK Defence Procurement CADMID process (Concept, Assessment, Demonstration, Manufacture, In-Service, Disposal) (RUSI 2012; MODAF 2005) lends itself to simulations in the Demonstration and early Manufacture (D&M) stages (Fig. 1).

Typically, the simulation of a defence system in the manufacturer's test laboratory is supported by a small number of subject matter experts (SME) from the end-users' organisation. There is, however a weakness in this, as the small number of SMEs involved during D&M will inevitably view the emerging product from a relatively limited perspective. In contrast, 'The Wisdom of Crowds' (Surowiecki 2004, p. 10) identifies the need for high degrees of diversity and independent perspectives before choosing a solution. The issue to be addressed is: **How to get a large number of people to share their knowledge and experience within the D&M stages of defence procurement?** This paper offers the Crowdsourcing of Serious Games as a solution and presents a status report following one year of academic study.

A. De Gloria and R. Veltkamp (Eds.): GALA 2015, LNCS 9599, pp. 61–70, 2016.
DOI: 10.1007/978-3-319-40216-1_7

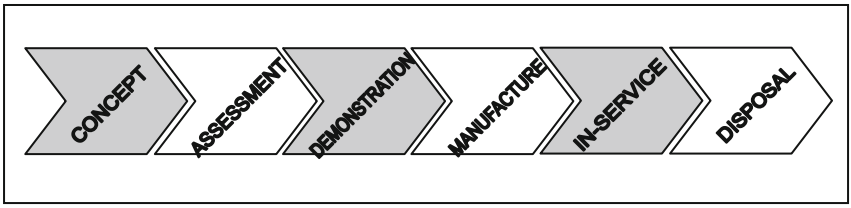

Fig. 1. CADMID Procurement Process described in JSP 886 (JSP 886 2015) is a linear procurement process designed to ensure defence systems are delivered to cost, time and quality.

1.2 Serious Games in Procurement

Serious Games for use at the Concept phase of defence procurement have been used within the Defense Advanced Research Projects Agency (DARPA 2015), where the game "ACTUV Tactics" was used to see what tactics might be developed for an unmanned submersible. Within UK, Niteworks (Niteworks 2015) acts as a focal point for government and industry partners to enhance future military capability where serious games might be used during the Concept phase.

Where the D&M stages begin to work with specific equipment capabilities the security requirements increase and this constrains the use of internet, allowing the use of defence intranet only. At this stage of the procurement process the capability has been defined and is passed to a project team for specific equipment implementation. It is at this stage of the procurement process that detailed human-machine interface design begins with a small number of subject matter experts (SME) working at the manufacturer's site. Simulations are again used with agreed scenarios to pre-view the final equipment and whole system performance. With the mechanics and dynamics of the system and its synthetic environment already in place, it is the addition of 'gamification' that would take the next steps on to a Serious Game and the hosting on a web server to allow Crowdsourcing. This study takes those next steps.

If these D&M phases fail to find the optimal design, then expensive re-work is passed to the In-Service phase following feedback from the end user community. This drives the need for a Crowdsourcing construct to engage a diverse community early in the procurement process. Although simulation based acquisition is offered as a generally accepted process, as evidenced in the UK's Acquisition System Guidance (AOF 2015), the use of Crowdsourced Serious Games within a defence procurement project is novel and untested.

1.3 Crowdsourcing in a Procurement Process

Broadly speaking, development and procurement are processes undertaken by separate groups of people, with their finished product being used by another group of people. It is the author's experience that the loss of fidelity as requirements are passed in the text-based documentation process – within the User Requirement Document to System Requirement Document to Top Level Specification - from one group to another leads to costly in-service re-work and reduced user satisfaction. This closed, text-based

process contrasts with a Crowdsourced game-based process that this paper proposes. The graphical interface provided by a Serious Game has the potential to convey the users' requirement in a more complete and meaningful way. When opened to defence users through Crowdsourcing a further benefit of agile design is offered.

Whether a project is run with 'big design up-front', or a more agile (DSDM 2015) 'enough design up-front' the user still needs to be engaged. With Crowdsourcing, that engagement is moved earlier in the procurement process. In the military context, user engagement can be impossible where the manufacturer is in a fixed location and the users are dispersed elsewhere in UK and on active service abroad. The crowd is geographically dispersed and groupings isolated. The medium for engaging the crowd, by default becomes the defence intranet.

1.4 Open Source in a Defence Network

As the game's functions and displays are developed incrementally through crowdsourcing, there has to be an in-house design and modification capacity to response to the users' feedback. In effect, the on-going design of the game becomes an Open Source project allowing users to propose coding changes and new function modules to the game.

It is possible for some commercial companies to have security clearances that allow access to the UK defence intranet. In such a case it is possible that the Serious Game development could be passed to a contractor. The down side of this is that the cost of the Serious Game would be added to the contract price. In view of this, an in-house Open Source approach is proposed.

A blog is used to allow feedback and discussions to take place. This also acts as a defence-wide media tool to advertise the game and encourage its use for fun, for game development, and for interface development.

In summary, the proposed concept is at the intersection of Serious Games, Crowdsourcing, and Open Source development.

2 Hypothesis

From the points raised above the hypothesis is that:

H1: Crowdsourcing with Serious Games for the design of defence equipment operator interface can be a more effective technique than current design methods.

The following will be used as measures of effectiveness.

H1a: The objective assessment of game score is taken as a Measure of Effectiveness when compared with the use of crowdsourced design features.

H1b: The objective assessment of time taken to achieve a game score is taken as a Measure of Effectiveness when compared with the use of crowdsourced design features.

H1c: The users' subjective expression of 'preferred' interface design is taken as a Measure of Effectiveness.

3 Methodology

The Serious Game is the central theme of the hypothesis, provides the vehicle for the Crowdsourcing, and by the nature of computer games provides a scoring value and duration from each game. The pre-developed game simulates an existing airborne maritime tactical display which has been in use un-altered for 20 years. The post-crowdsourced game will have all the features and displays suggested and added during the crowdsourcing process.

3.1 Game Overview

An example Serious Game was developed around an airborne maritime search task with a defined need to develop a new interface for an electronic warfare system. The specific case is an electronic support system where the users are given information on detected radars being operated against them. This is a surveillance task undertaken to develop situational awareness. Points are awarded for correct identification of ships and points deducted for incorrect identification. Time is limited by the fuel carried. The game has been in development through Crowdsourced feedback since September 2014. New functions and displays are being added throughout the Crowdsourcing period.

3.2 Objective Data Collection

Data Gathering. At the end of the Crowdsourcing period a controlled trial will be used for data gathering. Running the game in a web browser from a standard file server does not allow data logging direct to the server. Instead, a log file records the functions used and the scoring achieved during the game. This file is then offered to the user to attach to an automated feedback email. It would be preferable to record data from a wide variety of users in uncontrolled conditions to increase the sample size. The fact that the players will have access to the log files brings in to question the validity of the data if uncontrolled trials are used.

Game Scoring. The player scores points by the correct identification of ships in the game. At the start of the game there are 36 ships and as the sensors are used and detections made the ships' identification becomes known. This generates the score. In addition, the time-line is recorded with a more proficient operator, supported by improved displays, obtaining points faster.

Subject Matter Experts. A sample of users will be gathered, and ranked according to years of experience in the use of relevant tactical displays. The group will be divided alternately by factor rank into two groups. One group will use the pre-developed game first and the other the post-crowdsourced game first to allow for learning during the trial. Data log files will be recorded. The groups will then swap games and the same game levels will be played again.

Trials Repetition. As the game uses random numbers to seed the game scenarios, it is planned to play the game a number of times. There will also be a degree of game learning by the Subject Matter Experts and this will be objectively assessed in the data analysis.

3.3 Data Analysis

The analysis will take game scores and durations as a measure of effectiveness. The data analysis will take a matrix of consecutive function selections, and an array of durations that the functions were in-use. These will be compared with final scores and game durations. The data will be inspected for correlations between pre-development functions (those existing before crowdsourcing) and the game scores and post-development functions (those developed through crowdsourcing) and their game scores. A similar analysis will be made against the game duration variable.

3.4 Game Play Questionnaire and Interviews

As there will be a subjective element to the measure of 'more effective', described as 'SME preferences', a questionnaire will ask for Likert Scale preference for the functions offered in the game. For each function, pre and post development, the answers from these questions will be used to rank their perceived usefulness.

There will also be a free text area for each question allowing the user to give further opinion on each function. These free text responses will be used in individual interviews to obtain further clarity on expressed preferences.

3.5 Literature Review Questionnaire

The literature review has identified several cultural factors that are associated with crowdsourcing (Luttgens et al. 2014, p. 357). Although not taken as a direct measure of effectiveness, these cultural aspects could impact the use of Crowdsourcing and Serious Games within MoD. These cultural factors will be used in a questionnaire sent to all users from the Crowdsourcing development period. These questions are:

C**ommunity Identity.** To what extent do you identify with (feel a part of) this Serious Game community of players?
Consumer Producer. To what extent do you feel that you have control over the production of the tactical interface in the serious game?
Not Invented Here. To what extent do you resent the development of functions from outside the Procurement Stakeholder group?
Loss of Authority. To what extent do you feel that crowdsourcing subverts military authority and chain of command in the procurement process?
Social Media. To what extent do you think that social media web pages (Blogs, Ask A Question, Open Discussion) when hosted on defence servers are contrary to the military ethos.

Further cultural aspects may become apparent as the crowdsourcing activity continues and these will be added to the questionnaire.

4 Game Design in a Defence Environment

The mandated use of the UK defence intranet necessarily limits the code that may be used to create a Serious Game, as does the crowd from which an open source coding team may be formed. When selecting a language to work with it must be noted that Microsoft 'Notepad' will have to be the code editor, as no integrated development environment is available. The IE8 browser will have to be the interpreter and viewing window, but with the developer tools disabled. The crowd is likely to have been taught how to create a web page during schooling as part of the UK national curriculum and so will have been exposed to HTML and CSS. With these limitations in place the choice was made to initiate the Serious Game in JavaScript and jQuery. Various jQuery libraries could have been used to create the game, but given the expected rudimentary knowledge of web site coding within the crowd, a simple, universally applicable library (jQuery 2015) was chosen, with the benefit that any implementation of properties and methods would be explicit. With HTML5 and CSS3 not available, some Crowdsourced ideas required an alternative graphics package to 'Canvas'. The VML 'Raphael' library was chosen (Raphael 2015) as it is well documented on-line and in books. The basic routines of Timing Loops, Entity Control, and Z-Index manipulation are readily relevant and re-usable for anyone else wishing to build a game. A linked page is offered with advice on reference material and basic file structures for re-use. Attempts to connect with other people interested in writing Serious Games have not produced results.

Serious Games will often integrate with a server database to hold rankings and scorings. The UK defence intranet is tightly controlled and so this is not possible while retaining an agile Open Source coding theme. The game and all game files are held on a standard file server. Scorings are being held locally in a log file on the client and sent with other free-text feedback by email.

The subject of Game Design is well served by web sites and books. These were referred to and elements used to make the game attractive to many categories of user. Rigby and Ryan (2011, p. 139) identified: Competence (motivations to gain and display competence), Autonomy (motivations to control and direct one's own actions), and Relatedness (motivations to relate to others and achieve reciprocation) as reasons that people play games. The 'reward' scheme of on-screen medals was developed as a way of confirming 'competence'. The single-player game intrinsically supports 'autonomy', and the Defence Connect blog aims to support 'relatedness'. Other sources highlighted the need for a 'story'. Gibson (2015, p. 52), Iuppa and Borst (2012, p. 47), Thompson et al. (2007, p. 58) were referred to when writing the back-story and developing the story through the game levels. All of these aspects were developed from theoretical first-principles specifically for the UK defence environment.

5 Crowdsourcing the Serious Game

The benefit gained by seeking solutions outside of the traditional stakeholder community is summarised in Surowiecki's (2004, front cover) sub-title "why the many are smarter than the few", and by Page (2007, p. 158) as "diversity trumps ability". Page (2007, p. 162)

describes the process by which a diverse group use their range of heuristics and perspectives to move from one local optimum solution to an interim solution to another interim solution, all the time improving until the group decides that no more improvements can be made. This situation leads to a winning solution. Page makes clear that it's the range of perspectives and heuristics that is important not the numbers of participants. Even taking a large number of people with high ability, if they have been through the same education process or the same set of experiences their restricted range of perspectives and heuristics will be smaller than the diverse group, and therefore less able to reach a winning solution. It's for this reason that a limited number of SMEs embedded with the manufacturer are unlikely to find an optimal user interface design during the defence procurement process.

5.1 Game Development

The game began development in June 2014 and went live on the UK defence intranet in September 2014. Accessible from a file server, the game consists of one HTML file that then references several JavaScript files and jQuery libraries. No file is greater than 100 Kb and loads within a few seconds when tested across the network.

The electronic warfare task was chosen as it is a task undertaken by all three armed forces, thereby making it more likely that a diverse user community could be developed. The UK defence procurement process would normally limit its engagement to those identified as the 'stakeholders' in accordance with the Acquisition System Guidance (AOF 2015). The stakeholders are those who will use, support or be affected directly by the new equipment. This is what makes the use of Crowdsourcing within the MoD procurement process so radical. Instead of limiting the engagement to the stakeholders only, the Crowdsourcing process seeks to include a wide range of people who will be outside the stakeholder group and outside the electronic warfare group of specialists.

Crowdsourcing, and indeed the whole concept of enterprise social media was new to UK defence until the arrival of the Defence Connect. The mix of security accreditations and connectivity across defence networks has limited the crowdsourcing initiative as the game has to be run on the higher security accredited defence intranet infrastructure. Those who only have access to Defence Connect can take part in the Blog, but are unable to experience the game itself.

5.2 Early Results

Data Log files returned with users' feedback emails are processed using R statistical analysis software using the 'qgraph' library (qgraph 2015). A network plot is produced (Fig. 3) which allows analysis of consecutive function selections and duration spent within the game functions. This will give frequency and duration per function data which will later be compared with game score and game duration data to address hypothesis H1a and H1b (Fig. 2).

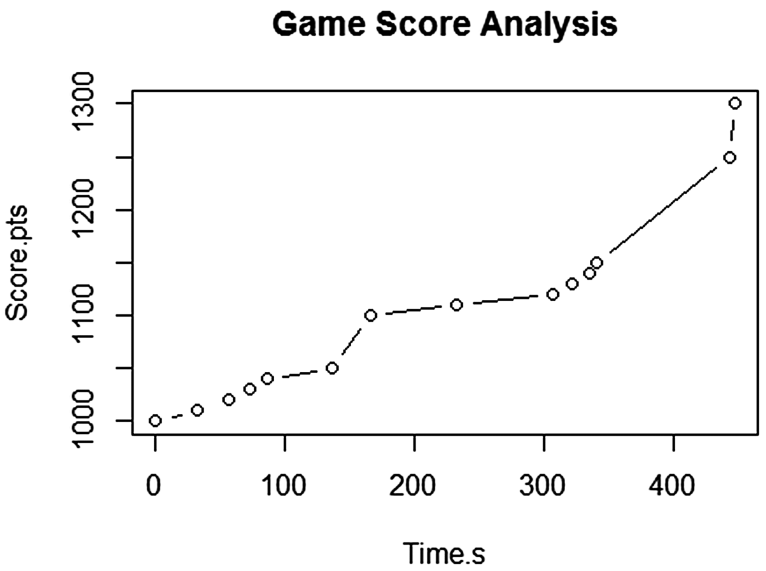

Fig. 2. The game score analysis plot from this one example game-play compares two measures of effectiveness: time, and game score. The increasing plot over time shows that all ship detections were correctly made. Incorrect identification of a ship gives a negative score.

6 Cultural Aspects of Gaming in Defence

From the description in the Game Design section there were significant technological issues. There are also cultural issues.

The Serious Game was developed as a 'grass-roots' activity without top-down direction. This contrasts with UK defence which is a strongly hierarchical organisation. While evidence has yet to be obtained through questionnaires, it may be that such a subversive action as playing a game without explicit direction from senior officers may be counter-cultural to the majority, and therefore unacceptable to be involved with.

Social media has been identified as being a security risk to defence personnel (UK Gov. 2011). While the younger people working in UK defence will have grown up with social media, the organisation tends to warn of the risks associated with it. This attitude is echoed in other western nations where press reports in relation to wiki-leaks is often seen as being 'bad for national security'. Future questionnaires will include specific questions to identify the effect of culture on the use of defence enterprise social media and the Serious Game in particular.

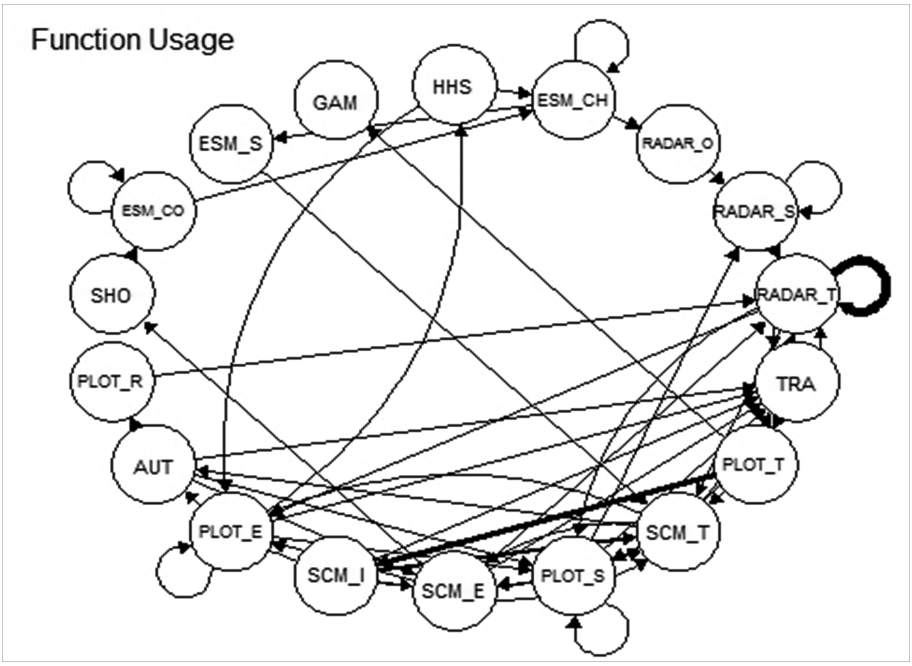

Fig. 3. Function usage provides a network of game functions used during a single game play. The functions are represented as nodes. The consecutive functions used are represented by edges. The width of the edges indicates the number of times consecutive functions have been used. For example, the thick line from and to the RADAR_T node shows repeated use of radar track while scan markers, and the PLOT_T to SCM_I line shows that track while scan markers are being passed to the inverse synthetic aperture radar mode for identification. A full legend and de-code has been omitted to save space in this short paper.

7 Conclusions

Simulations are regularly used within UK defence for training, but the use of a Serious Game to assist in the procurement 'Development and Manufacture' phases is a novel approach. A Serious Game developed to preview a user interface aims to reduce costly In-Service re-work and to increase user satisfaction.

To support an agile development process for the Serious Game, the UK defence intranet is able to support an Open Source coding team. With a blog on Defence Connect, a Serious Game is in use as a method of gaining a wide range of views and design ideas from inside and outside of the traditional procurement stakeholder group.

The use of Crowdsourcing for defence procurement has the potential to engage with a diverse range of people holding varying heuristics and perspectives. When filtered and aggregated by subject matter experts a Serious Game is proposed as a tool for learning and retaining corporate knowledge.

The use of games and enterprise social media within UK defence are at an early stage of acceptance. Culture and corporate norms of working practice will be subject to further study to understand blockages to progress.

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