Towards Gamification of the Ramp-up Process for Industry 4.0

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Abstract—**Keeping personnel motivated and overall company morale high is a crucial aspect of employee satisfaction. In manufacturing, various tasks can be found that can put a strain on personnel, one of them being the so-called ramp-up process. Ramp-up requires human intervention to bring a system to full production, but the process of achieving a successful ramp-up can be very cumbersome and lengthy. As this is usually a trial-and-error approach, spirits can get very low over time if the situation appears to only be slowly improving. For this purpose, gamification is introduced into the ramp-up process for Industry 4.0 to improve the ramp-up experience for operators. This paper offers an overview of the idea, current and future work of a web application for ramp-up that includes the major principles of gamification. The presented work is part of an ongoing student project work undertaken with the Intelligent Automation Centre at Loughborough University.**

Keywords— Gamification, Ramp-up, Industry 4.0, Game Design, Web App.

I. INTRODUCTION

Over the last few years, the focus of the manufacturing industry has been on a new paradigm, often referred to as Industry 4.0 [1]. In essence, the focus of Industry 4.0 is achieving end-to-end digitisation allowing for data creation, sharing and analysis to achieve a more sustainable production [2]. One area in the production life cycle that is known to be very time-consuming, is the so-called ramp-up phase [3], [4]. During that phase a production system is taken from low- to high-volume production, which requires tweaking of system and process settings until the required functionality, product quality and performance are reached [5]. This can be a tedious undertaking as no two systems are the same and no manual for ramping up a system exists [6].

In this context, this ongoing work proposes to use the concept of gamification to assist in the ramp-up process. The idea of increasing the performance during ramp-up using a gamification approach is not new [7]. However, work and knowledge in this area are still very limited and to the best of the authors' knowledge, no web application for ramp-up exists to date. For this research work, gamification is understood as "a tool to increase productivity and morale within a company by using elements of game playing, which can also be used for encouragement". The underlying tenet is that through increasing motivation through the gamification introduction a smoother ramp-up process can be ensured as reinforcing training can be given to the operator. For this purpose, this work will develop a web application to assist the user during the ramp-up process that contains elements from gamification.

A. Project Aims and Objectives

As part of this, research into the design and the development of a useful gamification web app for the ramp-up process, the following aims and objectives will be addressed:

- Identify key aspects of the project for Literature Review including defining Gamification, Ramp-up Process and Industry 4.0.

- As part of the literature review find relevant case studies.

- Determine how Gamification for Ramp-up Process can be linked and how Industry 4.0 links with Gamification and Ramp-up as part of the literature review.

- Design one proposal for experimentation, use case study information found to develop proposal.

- Validate the chosen proposal within the laboratory and collect data from an experiment.

- Gather feedback on ideas through a questionnaire to ensure that game designed matches gaming habits in current society.

II. GAMIFICATION APP DESIGN

To start the project, extensive research was conducted to ensure that all topics were understood. From this, a Product Design Specification (PDS) was created that assists in the design process. The initial design process included designing the social side of the game including the user profile page, the forum page and game mascots. The initial game designs included a quiz-based game, a timer game and 'Build a Toolbox' game. However, the latter seems to have the most potential to be developed. These aspects are briefly described in more detail below.

A. Profile Page

Every user will be able to set up a profile page. Some of the information included will be achievements, skills the user has and any information the user would like to include. Other information they could add may include their job title, education, a fun fact, and their company details. The user will also be required to create an avatar that would act as their virtual representation. The user will be able to choose the sex, skin colour, hair colour, hairstyle, eye colour, clothing etc.

B. Forum Page

The forum page is a way for users to interact with one another. Some of the aspects of the forum page include a news feed for the company's latest news, a way to see other people's posts and a way to react and comment on them.

C. Game Mascots

The idea of a mascot is being considered to capture the user interest in the game. The mascot will fit into the game by giving the user the instructions of how to use the game along with any training the company deem appropriate. The initial ideas shown in **Fig. 1** are "Robbie the Robot", "Ruby Ramp Up" and "Engineer Dave". However, any mascot idea would

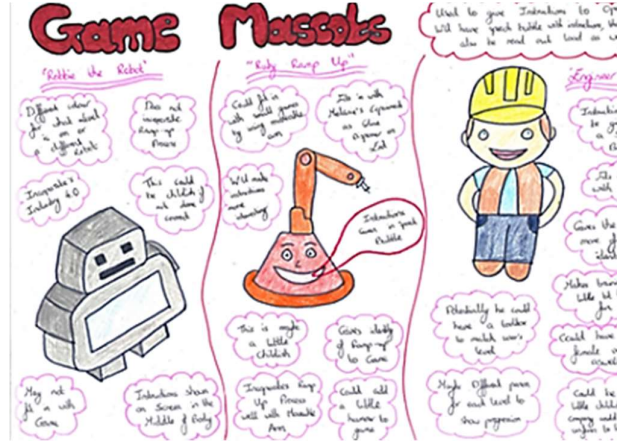need to be developed alongside the game for it to fit within the game environment.

Fig. 1. Initial design ideas for the game mascot.

D. Build A Toolbox Game

The user will gain points through completing the ramp-up process to compete in this game. For example, 5 points for finishing the process and 1 point for every test run. As the user gains more points, they can buy tools to go in their virtual toolbox. Once a toolbox is full, they move to the next size toolbox. Special tools could also be awarded to show that certain training has been completed, which could be a way for senior managers to see what training operators have had. To keep the user interested in the game, small games could be introduced, for example completing a puzzle, for when the ramp-up process is running. This could also be a way for the user to build more points up to buy tools.

III. INITIAL QUESTIONNAIRE

Alongside the design process, an online questionnaire was designed and distributed to help determine peoples' gaming habits and their initial thoughts on the game ideas. A total of 125 responses from 125 participants was gathered. Information about survey participants can be summarised as follows: Participants mainly have a non-technical or manufacturing background (63.2%). The majority of participants was female (66.4%). Participants majorly fell within the age range of 46-55y (34.4%), followed by 36-45y (20%) and 18-25y (19.2%). A higher percentage of participants currently plays games (64%). Most of the games are played on the mobile phone (70.4%), as board games (50.4%) or on game consoles (46.4%) (multiple choices apply). The types of games that are mostly played are puzzles (54.4%) and board games (51.2%) and action (39.2%) (multiple choices apply). Besides general questions about the participant's gaming habits ("Do you currently play any games, or used to play games?", "Do/Did you interact with other people when playing games?", "What type of games do/did you mostly play? ", etc.), questions related to gamification were also asked. This allowed identifying whether people have previously heard of the term and what their understanding of it is. When asked about gamification, only 8.8% have ever heard of the term prior to participation. Where definitions were given, these described the key ideas of gamification very well, i.e. trying to improve a process, incorporating elements commonly used in gaming (trophies, leader boards, statistics), making a process psychologically rewarding, being motivative.

IV. CASE STUDY

An industrial-like scenario will be used to test the game, once developed. The designed use case focuses on ramping up a robot cell for a dispensing process, that will require participants to change different process and hardware settings [8]. These settings will have to be captured by the participants through a developed graphical user interface (GUI). The robot cell consists of the following main components: a single ABB IRB120 6-axis industrial robot connected to an IRC5 controller, a two-finger gripper to hold metal plates during robot manipulation, and an automated time-pressure dispensing unit (Fisnar JB1113N). A simplified overview of the setup can be seen in **Fig. 2**. The participants will be asked to produce three different products that differ in their produced pattern. For that purpose, participants will have to set different process and equipment settings before testing the setup to reach certain key performance indicators that deem the ramp-up successful, such as product quality and cycle time. Changes that can be made to the system include different sizes of syringe nozzle, varying robot speed and dispensing pressure. Participants will be divided into two groups, where one will interact with the developed web app within the ramp-up GUI, and the other will not. In that way, the usefulness and user-friendliness of the developed app can be evaluated. Besides comparing KPIs related to the effect of gamification to achieve a successful ramp-up, such as time required to get the setup to volume production, a post-questionnaire will capture more subjective information like engagement and fun with the app, but also the level of distraction.

Fig. 2. Overview of the setup for the robotised dispensing experiment.

V. FUTURE WORK

The main focus will now be on the implementation of the actual gamification web app. Currently, different programming languages are assessed to identify the best suitable one. During the implementation, frequent feedback from an academic but also industrial perspective will be sought to ensure the usefulness of the game. Once the app has been finalised, testing on the previously described use case will be undertaken. Moreover, to assess the user-friendliness of the game, another questionnaire will be distributed to participants of the experiment.

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