Investigations into the Development of a Knowledge Transfer Platform for Business Productivity

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***Abstract* –There is a lack of access to training tools, best practice guides and knowledge repositories to help with the digital switch to Industry 4.0. Consequently, in this paper, the ProAccel (Productivity Accelerator) platform design is outlined. The system is a modular cloud-based multimedia platform that employs advanced data analytics and gamification techniques, such as Virtual Reality (VR), to revolutionise the way productivity information is shared to support businesses in their uptake of digital technologies in the Industry 4.0 environment. We present our findings from a 4 month case study, involving over 100 UK-based companies. The resulting research was used to construct a prototype of the ProAccel platform. As an evaluation, a simulated user evaluation of the platform using a guestimate model derived from a KLM analysis is conducted as an analysis of the platform's functionality.**

Index Terms* – *Industry 4.0, Productivity, Education, Knowledge Management, Internet of Things, Smart Homes, Virtual Reality.

I. Introduction

The remote access to data is enabling manufacturers to improve their productivity through optimising traditionally laborious processes. Companies are able to reduce production times and up-scale their services through intelligent digital resource allocation using a combination of Internet of Things (IoT)-ready sensors, smart home devices, cyber-physical systems, cloud computing and cognitive computing [1]. These tools are providing new opportunities to deliver traditional services. With the addition of machine learning, these smart technologies have room to expand, thus saving more costs in the future [2].

The other aspect of the IoT is that most technology is cloud-based making it accessible instantly, changeable and interactive from a variety of devices and locations. With the constant analytics from smart sensor technology, in turn, creating big data, new opportunities can arise from collecting such varieties of data for analysis and improvement of a manufacturing process. Only now with smart technology gathering big data can we truly see where improvements need to be made and identify or predict faults in a manufacturing process. With this kind of automation, a manufacturing machine can be turned off autonomously to save future waste or further damage [3].

Clearly, access to knowledge and its appropriate management has the potential to influence and improve private and public organisations. Some of the issues faced are a business' ability to recognise its own need to modernise and to get the correct guidance while doing so. A further goal, as much as speeding up production, is to de-risk; Where virtualisation has proven that simulating an act before it occurs, in reality, reduces risks and costs to companies or people.

With the emergence of smart technology and Industry 4.0, we live in exciting, fast-paced, constantly changing times. The exponential rate at which computer technology has always moved forward, some expect smart technology and AI innovation to do the same. The car industry is benefitting immensely with its leap forward into Industry 4.0, where we are already seeing modern cars with assisted driving and integrated GPS navigation, auto-inflating tyres depending on the terrain or fully autonomous driverless cars [4]. Another example is the advertising domain, which has been completely revolutionised with smart technology, for example, targeted ads; camera analytics that can detect facial and body language, then give the appropriate response with an advert.

Yet, within this growing Industry 4.0 environment, there is a lack of knowledge sharing, guidance on data management practices or understanding of how integrating 4.0 technologies can improve the workflow in businesses that have not yet integrated technology into the production process. As such, in this paper, an extension of our research into the design of ProAccel outlined in [5] is presented. The platform is designed to be a knowledge transfer platform for UK businesses to enhance business productivity through data analytics and gamification techniques integrated into a modular cloud-based platform [5].

This paper is organised as follows. Section 2 provides a background discussion on the three technologies being employed by manufacturers in the Industry 4.0 switch. Section 3 discusses the ProAccel platform and outlines the technology used for its deployment. In this section, the results of a simulated user evaluation are also presented. The platform is evaluated in Section 4 and a discussion about the platform is put forward. The paper is concluded in Section 5.

II. Discussion

UK productivity lags behind France, Germany, and the US by up to 30% according to the Office of National Statistics [6].

Since the financial crisis of 2006-2007, the UK has struggled to enhance the productivity per worker, compared to most European countries. As such, we outline three key areas of technology that have the potential to improve business productivity within the UK.

A. Machine learning

Interest in machine learning has been on a steady climb since 2013 and its current trend line predicts this interest will continue to grow, as highlighted in Figure 1.

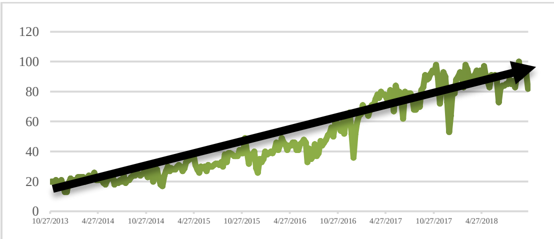


Figure 1. Machine learning interest worldwide

The deep learning formula of machine learning strategy is expected to become a commodity in all 4.0 businesses in the UK. Now in 2018, research suggests a large number of companies are now ready to implement such strategies into their systems; as demonstrated in Figure 1. Statistics from the UK Government state that data-driven companies are at least 10% more productive than those that are not [7]. However, most of these companies are not utilising their data as they should. This is where the digital revolution of machine learning has changed the productivity landscape. Introducing machine learning to all data-driven companies and modernising those that are not, will help speed up and evolve current processes, speed up automation, reduce medial tasks and the complexity of issues.

B. Virtual Reality

There has been significant interest shown in Virtual Reality (VR) from 2015 onwards, the highest spike in interest was on Christmas Day 2016; this day marked the event when VR headsets had entered the mainstream and it became a worldwide platform in homes across the world, as outlined in Figure 2.

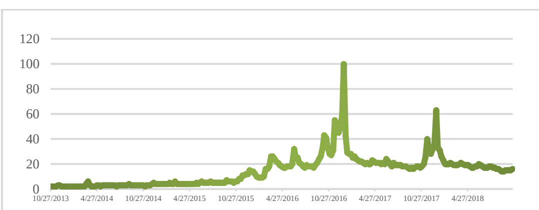


Figure 2. VR interest worldwide

The VR/Augmented Reality (AR) platform shift is the fourth major platform shift after PC, web and mobile. It is still a relatively new platform in terms of business modelling. Major companies have invested large amounts of capital into VR over recent years. For example, Facebook paying over $2 billion for the acquisition of Oculus, which is also partnered with Samsung VR. According to findings from Digi Capitals, revenue forecast 2017, VR business revenues could reach over $120 billion by the year 2020. The ambitions of VR are unsurmountable as they aim to replace machines like desktops and laptops. Test models of this have already been implemented, one of which is in the ISS space station.In 2021, the VR/AR market is expected to reach a market size of $251 billion. Revenue from VR software alone is expected to rise by over 3000% percent in next 4 years. The technology firm Envelop have already designed a prototype VR plugin for Excel, demonstrating the market interest in trying to increase productivity [8].

The application of VR/AR in the construction industry would enable a much more proactive and hands-on role for clients in design phases. Virtual mock-ups can utilise real-world dimensions and assist in early flaw recognition. VR has the potential to save time and money. For example, any practical, real world expensive changes can be avoided, before real time issues and delays arise. Modern Autodesk innovations (e.g. Autodesk Live), enable architectural immersive environments straight from a Building Information Modelling (BIM) model or plugins to visualise 3D models interactively in VR instead of on a screen with a mouse. Safety training aspects of VR could revolutionise safety training on or off site.

C. MOOCS

The Massive Open Online Course interest on Google searches has shown a repetitive increase and decrease each year but the average interest continues to rise, as shown in Figure 3.

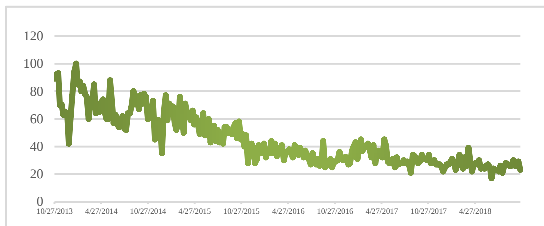


Figure 3. Massive Open Online Courses interest Worldwide

There are constant 6-month lows and highs spread over a 5-year period on this graph showing the MOOC interest does have seasonal or term-time interest. At the start of the ProAccel project in 2017, the global MOOC landscape had grown to encompass over 9,400 courses, providing more than 500 accreditations [9]. In 2017, it is estimated that around 23 million new learners signed up for their first MOOC, which is an increase of 37% on the previous year. At the beginning of 2018, the total number of active MOOC learners is estimated to be over 81 million worldwide [9]. In addition, some MOOC providers are starting to provide fully-online degrees. The forerunner in this Coursera, which will be offering 10 online degrees in partnership with leading universities by 2019 [10]. . According to data gathered by Class Central, around 23 million new learners signed up for their first MOOC in 2017 [9].

MOOCs were first started as a free service; however, this has proven to be an unsustainable business model. As the MOOC platforms continue their quest for more sustainable revenue models, MOOC providers have begun shifting toward freemium and premium models, charging not only for certificates and other accreditations, but also for access to content.

In the following section, the ProAccel platform is presented. The three key technology areas outlined in the background discussion are integral in platform design.

III. Platform Overview and User Evaluation

The ProAccel platform is a unique business-centric and community driven environment, underpinned by the latest computer science research, e.g. artificial intelligence, machine learning, augmented reality and VR. Furthermore, utilising a cloud-based approach facilitates technologically-independent access for businesses, including a responsive design for mobile device compatibility. The structure of the platform is presented in Figure 4.

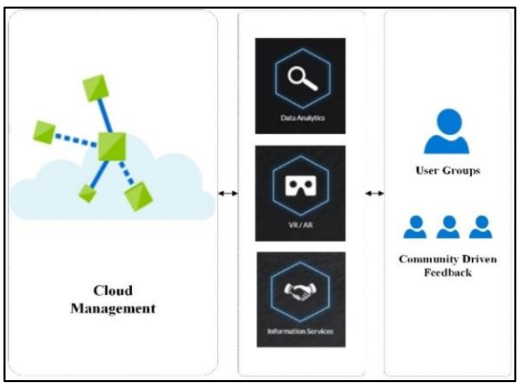


Figure 4. Platform Prototype Overview

The platform originally offered six services (as outlined in [5]); however, after the business consultation process the platform was refined to offer three core services with other services either removed or merged. These services include 1) a Data Analytics module, 2) a VR/AR intelligent tools repository and 3) an Information Service.

A. *Platform Overview*

Figure 5 shows the home page for the ProAccel platform. The user has the option to select one of the three services, which are given prominence within the page layout. Due to the platform being a prototype, an evaluation is conducted through Ozzie Gooen's Guestimate (OGG) model. Timings are adopted from the Keystroke Level Model (KLM), which are industry standard operation times for the corresponding action [11]. Task A involves assessing the core functionality of the platform, which is finding and using one of the services. In Figure 6, the graphs show the estimated time for the 4 actions required to access one of the services.

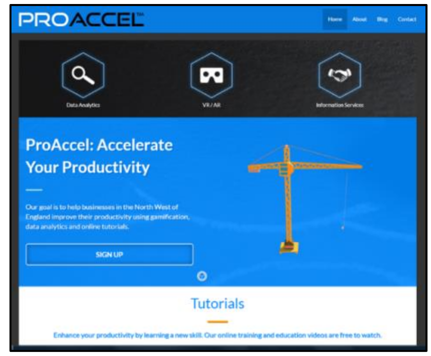


Figure 5. ProAccel Prototype Home Page

The various interactions required to access one of the ProAccel services. 1) Mental preparation, 2) Homing in on the keyboard, 3) Pointing the mouse and 4) Clicking the mouse.

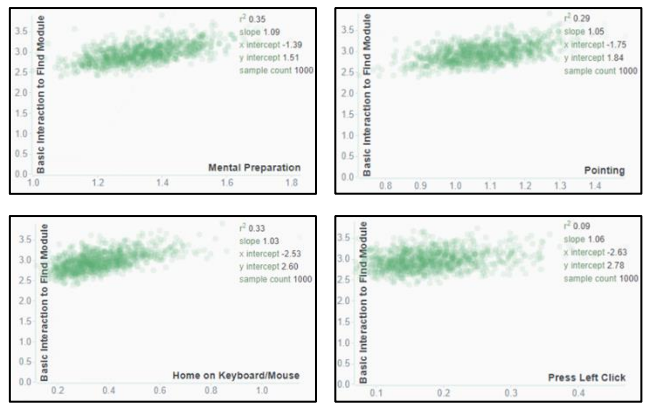


Figure 6. Estimated completion time for module selection actions

If the primary goal of the platform is to reduce time on task, and improve productivity, then the OGG analysis allows the team to refine the product prior to user testing taking place. The model simulates the testing of 5000 users with the results generating an average time of just under 3 seconds to access one of the platform modules, as displayed in Figure 7.

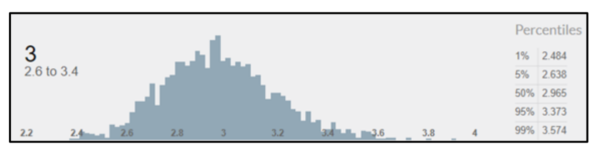
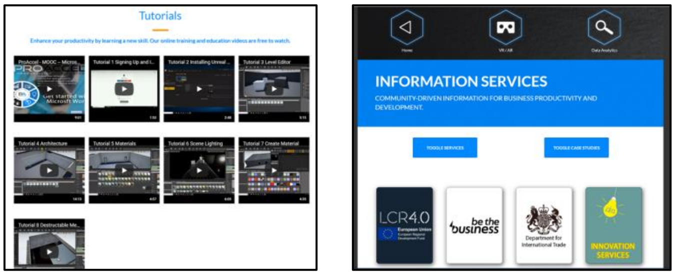


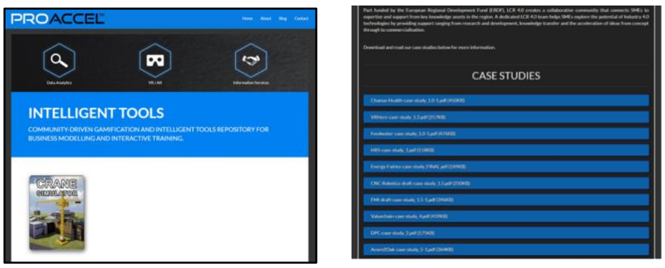
Figure 7. Module access on the platform

As the platform is in prototype stage, the use of OGG ensures that slight modifications in user interaction timings are accommodated for prior to deployment. Figure 8 displays the MOOC service (which is integrated into the landing page) and the Information Service module. Whereas, Figure 9 displays the Intelligent Tools repository and a data repository (which is part of the Information Service). The following use-case task (Task B), involves accessing a tool within one of the services. Figure 10 outlines the additional user interaction stages required in order to access a tool. The interaction process, to locate the desired service and select a product within the service takes on average 20 seconds with the median time being 16 seconds, as displayed in Figure 11, with 3 seconds being the fastest and 70 seconds being the slowest estimated interaction times respectively.



(a) *(b)*

Figure 8. (a) Prototype MOOCs, (b) Prototype Information Service



(a) *(b)*

Figure 9. (a) Prototype Intelligent Tools Repository, (b) Industry 4.0 Case Studies

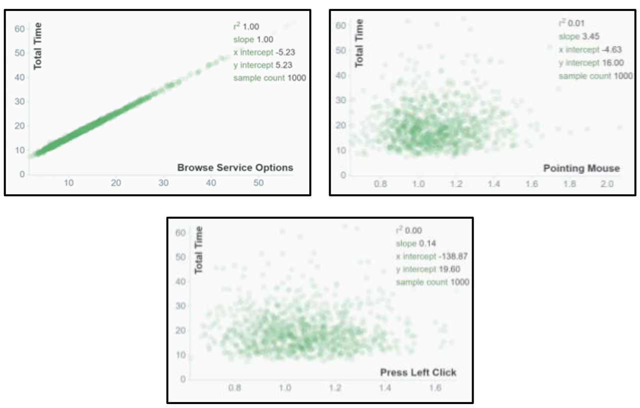


Figure 10. Estimated completion time for product selection within service

Figure 12 shows a comparison of interaction times for Task A vs Task B.

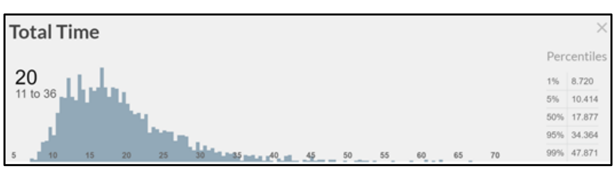


Figure 11. Product access on the platform

As the evaluation shows, the platform interaction is rudimentary and the tools accessing process is streamlined to ensure that the platform can be interacted with as efficiently as possible.

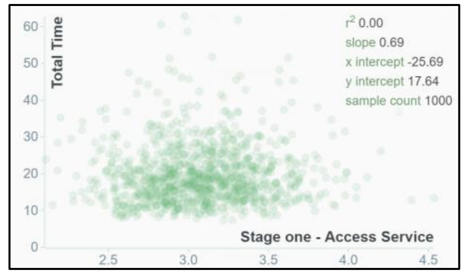


Figure 12. Task A vs Task B

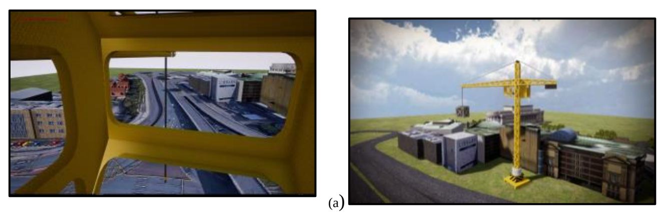
This final design and interaction process was made possible through consultation with over 100 UK businesses, as previously outlined. The accessible tools within the platform are presented and evaluated in the following section.

IV. Platform Tools Demonstration

As the ProAccel platform is in a prototype stage, two intelligent tools are provided as a demonstration of the technology that can be used to streamline productivity within a business setting. In this section, an initial evaluation of the tools is presented. Both tools have proven popular when presented to companies during the project.

A. *VR Tool*

A simulation of a crane is provided as a demonstration of the technology that would be integrated into the full platform implementation.



(a) (b)

Figure 13. (a) ProAccel Prototype Crane Tool Simulator Cockpit (b) ProAccel Prototype Crane Tool Simulator Overview

The crane can be used to train drivers/operators in a safe environment, improving the productivity behind the training stage of crane operation. Our prototype example aims to train crane workers in both 2D and VR within real-world virtual cities. A visualisation of the view from the crane cockpit is presented in Figure 13a. The application allows the user to move the crane around and the view changes dynamically. As well as this, the prototype shows where a crane can be positioned within a real-world 3D virtual environment, taking into account the swing and rotation of the crane beam. An interactive demonstration allows workers to pick up equipment and manoeuvre it over a building.

If collisions occur, real-time shader technology is employed to render hit objects in red. Real-time physics calculations are also employed to dynamically destroy the said building. This prototype conveys the importance of view perspective from the eyes of the crane worker, allowing them to make mistakes in a virtual safe environment. This is presented in Figure 13b.

Table 1 presents the KLM interaction times for the VR crane simulator. The interaction is tested on a PC, but in full deployment will be interacted with through use VR controllers (such as the Oculus Rift Touch Controller). By using this approach, actions within the game and their corresponding interaction times are clarified. For example, a simple task such as turning (rotating) the crane would involve the following stages, where *n* the number of times a user performs the action:

$$Task\ A = M+H+ (Kl * n) + (Kr * n) \tag{1}$$

TABLE II. KLM Interaction Times

KLM Interaction Times - PC		
Task	Time (seconds)	Abbreviation
Mental preparation	1.35	M
Home on Keyboard/Mouse	0.40	H
Pointing	1.10	P
Press left click	0.10	Kl
Press right click	0.10	Kr
Turn left (A Key)	0.28	Kl
Turn right (D key)	0.28	Kr
Move Backward (W key)	0.28	Kb
Move Forward (S Key)	0.28	Kf

However, the use of OGG ensures that slight modifications in user interaction timings are accommodated for (particularly as the game environment is open plan; meaning haptic values can readily change based on user familiarity with the software/hardware).

TABLE II. KLM Interaction Times

OGG Interaction Times - PC		
Task	Value Range	Abbreviation
Mental preparation	1.2-1.4	M
Home on Keyboard/Mouse	0.2-0.6	H
Pointing	1.0 -1.2	P
Press left click	0.1-0.2	K(l)
Press right click	0.1-0.2	K(r)
Turn left (A Key)	0.18 – 0.38	K(l)
Turn right (D key)	0.18 – 0.38	K(r)
Move Backward (W key)	0.18 – 0.38	K(b)
Move Forward (S Key)	0.18 – 0.38	K(f)

Based on the results from the OGG analysis, it is evident that interacting with the VR application is straightforward for the basic crane movement tasks.

B. Data Analysis Tool

Within the platform, a data visualisation app allows companies to insert Financial Analysis Made Easy (FAME) data and based on location, view profitable companies or organisations making a loss. The visualisations are constructed through use of force directed graph algorithms, as demonstrated in Figure 14. For example, the algorithm applied for the visualisation uses the repulsive forces on one node from a cluster of distant nodes. The algorithm calculates both the attraction and repulsions forces to visually in order demonstrate the component nodes within the dataset. This allows for related information in the data to be visually closer to other related information; whereas unrelated data is pushed away forming separate clusters. Visualising data in this way allows users to see anomalies within the dataset, such as underperforming over-performing companies.

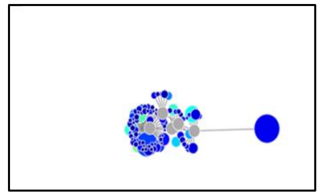


Figure 14. ProAccel Prototype Data Visualisation Tool

V. Conclusion and Future Work

In this paper, an analysis of the user-interaction processes in the ProAccel platform are outlined. Throughout the project development process, our market research has proven that there is a need for the services offered through ProAccel. The market research has uncovered that there is a distinct lack of technologic knowledge in specific domain areas that can improve productivity. Using VR and data analytics, complicated and time-consuming processes can be streamlined. As such, our future work will involve on-going community-based feedback for the development of the full-scale platform.

Acknowledgements

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