Applying Gamification Principles to a Container Loading System in a Warehouse Environment

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Abstract. Gamification is a recent phenomenon that emphasizes the process of incorporating game elements, for a specific purpose, into an existing system in order to maximise a user's experience and increase engagement with the system. In this paper, we discuss the effects of the introduction of the principles of gamification to a system for solving real-world container loading problems in a warehouse environment. We show how user engagement and confidence increases over time during interaction with the 'gamified' system, and we propose subsequent work for the thorough application of gamification to the system that completely abstracts the complicated container loading algorithms running in the background.

Introduction

Gamification is a phenomenon that has in the last few years garnered a lot of attention with numerous applications particularly focusing on productivity and health fitness. It is defined as the use of game design elements in non-game contexts [1] and is mostly introduced into a system to increase user experience and user engagement [2], or to act as the means of actual user engagement where there is none. The increase in experience and engagement is considered to be the result of the effects obtained when leveraging people's natural desire for learning and accomplishment.

In this paper, we discuss the application of the principles of gamification to a container loading system used to assist warehouse operatives during container loading in a real world warehouse environment.

We discuss the effects this has on the adoption of the container loading system, and show a systematic build-up of trust and familiarity over time of the system by the operatives. We then propose a fully gamified system as an abstraction that provides an interactive environment for the engagement of warehouse operatives with what would be otherwise complicated algorithms that solve container loading problems.

1 Background

Information technology systems have long since been introduced into the workplace to bring about an increase in business performance [3,4, 5,6, 7]. The phenomenon of introducing gaming elements in a nongaming context in order to increase engagement, is generally referred to as gamification [2]. This can be illustrated by our case study of a real world problem in a UK distribution centre (henceforth known simply as the UKDC) of one of the largest industrial bearing suppliers in the world.

The problem the UKDC faces is that of optimally selecting and loading groups of palletised goods onto containers. The palletised goods, typically spread across different locations in a warehouse, are heavy and require the use of fork-lift trucks to move, stack and load them. The goods are made up of boxed bearings which are packed into cartons that are arranged on any of several different pallet types, which are then shrink-wrapped and treated as individual units. Several practical constraints must be satisfied in order to produce a feasible solution to the problem.

To solve this important problem optimally, the UKDC have invested in research towards a computerised loading optimisation system in a bid to: i) increase overall loading speed: ii) reduce the cost of hiring containers by optimally maximising the capacity of every loaded container to reduce overall number of containers used for loading; iii) reduce damage to goods that might occur because of non-optimal packing in the container, therefore reducing costs that might arise from replacing damaged goods, or customer fines for the receipt of damaged goods; iv) provide greater customer satisfaction by speedily processing and loading customer orders for safe and prompt delivery, and v) increase warehouse throughput: the more goods that are loaded and sent out from the warehouse, the higher the warehouse's capacity to process new customer orders with the existing space, which could lead to more business for the company.

We refer the reader to [8] [9] for the more fulfilling aspects of the jobs of the warehouse operatives who currently perform the planning and loading operations. It did not help that the output of the initial system prototype was plain text data (Figure 1), with numbers tersely showing item dimensions, weight, group membership, coordinate point locations, etc., that was difficult to interpret by the operatives. It also did not help that almost all the solutions produced from initial test runs consistently obtained 100% container utility (compared to the average of 85% utility from manual loading).

Related Work. As gamification research is still in its infancy, several varied definitions exist for it in literature: Deterding, Nacke, Dixon and Khaled in [1]; Zichermann and Cunningham in [10]; Huotari and Hamari in [11]; and Werbach and Hunter in [12]. The important point in this definition is the presence of a purpose; the game elements incorporated into a system must have a specific purpose if an improvement in user engagement and motivation is expected [7].

Li, Grossman and Fitzmaurice in [13] gamified a tutorial system to help new users learn AutoCAD. McDaniel, Lindgren, and Friskics in [14] introduced gamification, through the use of badges as a sign of achievement, into a learning management system to motivate students towards certain behaviours desired by teaching staff. De-Marcos, Garcia-Lopez, and Garcia-Cabot in [15] studied the effects of gamification on learning performance in an undergraduate course.

2 Gamification Approach and Experiments

Our main goal was to ensure and increase user engagement in the loading system. We identified from literature that the application of gamification principles was a good fit for this goal, and we set about identifying areas in the underlying system that could benefit from such principles. Table 2 shows the gamification sub-goals we set and the eight strategies we identified for tackling them. In the rest of this section, we discuss our implementation of some of these strategies and outline some of the observations resulting from the exposure of the resulting gamified system to the warehouse operatives. The remainder of our observed results are discussed in the following section.

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Best Solution:
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Selected Groups: 0002, 0004, 0005, 0015, 0029
Total Weight: 25948kg
Summary (54 items): E-TYPE (12), S-TYPE (22),
    N-TYPE (20)
GROUP0002/00001, W: 294kg, LBH: 80/70/74, STK:0
GROUP0002/00002, W: 592kg, LBH: 105/75/71, STK: 1
GROUP0002/00003, W: 391kg, LBH: 80/70/92, STK: 1
GROUP0002/00004, W: 279kg, LBH: 80/70/72, STK:0
GROUP0002/00005, W: 401kg, LBH: 120/81/76, STK:0
GROUP0002/00006, W: 495kg, LBH: 105/75/69, STK: 1
GROUP0004/00001, W: 292kg, LBH: 80/70/58, STK:0
GROUP0004/00002, W:700kg, LBH:120/81/60, STK:0
GROUP0004/00003, W:676kg, LBH:120/81/76, STK:1
GROUP0004/00004, W:816kg, LBH:120/81/76, STK:0
GROUP0004/00005, W:503kg, LBH:120/81/60, STK:1
GROUP0004/00006, W:601kg, LBH:80/70/92, STK:1
GROUP0004/00007, W:700kg, LBH:120/81/76, STK:1
GROUP0004/00008, W:660kg, LBH:120/81/76, STK:0
GROUP0004/00009, W:661kg, LBH:120/81/92, STK:0
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Figure 1. Example text output from initial loading system.

2.1 Defining conventions for visual layout representation

Our first steps involved building a visualisation for the text data output of the loading system (Strategy 1). The visual representation is provided as a container layout that shows the exact placement of colour-coded palletised goods within a container (Figure 2). In subsequent interaction with the loading system, all loading operation results were presented using this visual representation.

Problem	Goal Strategy	Goal Strategy
System adoption is low and system output is dull, non-engaging and difficult to interpret	A. Engage users visually with an intuitive interface	1. Present an interface with intuitive loading representation that is easy for users to use and understand
	B. Retain user engagement and make system fun	2. Ensure the interface is simple and can make loading tasks fun
		3. Provide loading 'challenges' that can be rewarded with special badges or trophies
	C. Encourage user learning, improvement and knowledge sharing	4. Implement a scoring system to leverage user competiveness which makes users want to do better than others at loading tasks
		5. Provide repeatable tasks, which can be used in conjunction with score feedback, to reinforce learning
		6. Record completed user tasks that other users can easily access and learn from
		7. Provide users with a way to interact with the results from the loading system in order to allow modifications that result in new solutions
		8. Provide an interface that allows one to quickly and easily check if a particular load layout will fit in a container

Table 2. Identified gamification strategies and goals for the system.

Our observations of these interactions revealed that our conceived visual representation, while a step in the right direction, came across as rigid and final to the operatives. This observation informed the need for a more flexible interactive interface, and became the basis for the identification and implementation of Strategy 2 and Strategy 7.

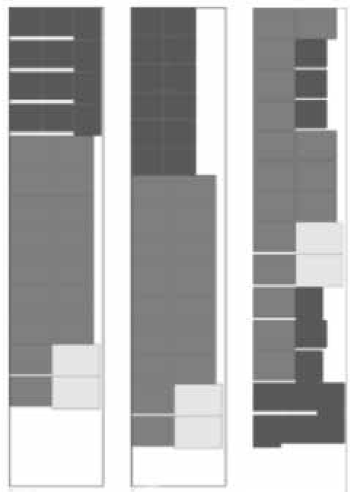

Figure 2. Visual representations for loading system output.

2.2 Providing an interactive simulation interface

In other to provide an interface that would be fun and interesting (Strategy 2), we decided to build a simulation interface that would incorporate the same visual representation conventions we had previously defined (Figure 3a).

We made this interface accessible on a tablet because of its ubiquity and mobility; the idea being that the warehouse operatives would find it very familiar and easy to operate. We then presented the simulation interface in a manner that vaguely resembles the game ‘Tetris’. This helped loaders check and reinforce their own loading knowledge. As part of our continuous evaluation of the system, this observed interaction helped further inform the gamification goals and became the basis for the identification and implementation of Strategy 8.

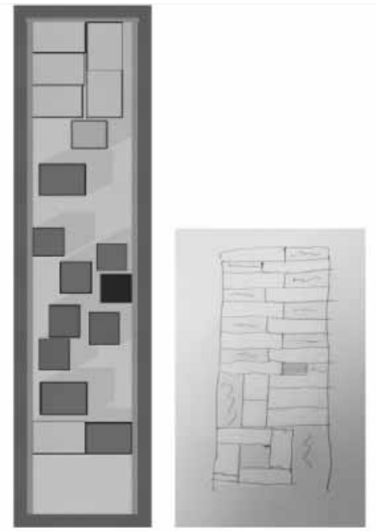

Figure 3: (a) Interactive simulation interface for the loading system. (b) An operative uses our colour scheme when sketching a suggested layout.

Pallet name	Pallet dimension ratio	Colour
E-Type	12 x 8	Yellow
S-Type	8 x 7	Blue
N-Type	10.5 x 8	Red
E2-Type	8 x 6	Green

Table 1. Defined convention for layout representation.

3 RESULTS AND DISCUSSION

Our visual representation convention has now been internalised so much that it is used in the day-to-day discussion of general loading activities, not necessarily related to the loading system, in the warehouse (Figure 3b).

In our initial gamified representation of the loading system output, users were presented with loading layouts as seen in Figure 2. This feature alone caused a significant increase in user engagement with the system.

3.1 Use Case: Loading Feasibility Checker

The system can be used to check if a load can fit completely into the simulated container.

As the simulation is built to scale, if the load fits in the simulation, it will most likely fit in the real world. We remind the reader that the real world loading operations involve using fork-lift trucks to move around heavy goods; it is easier, faster and safer to plan out such activities first in the simulation and then loading, rather than directly proceeding with physical loading and trying to rectify any issues that develop as they manifest. This particular complementary behaviour of the system has proven to be very useful to the operatives.

3.2 Use Case: Knowledge discovery tool

The system has sometimes generated and presented loading layout patterns that the loaders have never experienced or implemented before. A common comment received from the users regarding this behaviour is “I never would have thought to do it that way”. Some of these interesting loading layouts allow the loaders to pack more goods onto the container than they previously thought possible; others introduce entirely new ways of packing loads efficiently. The loaders have adopted these new patterns and started to apply them practically to their loading operations in the real world (Figure 4 and Figure 5).

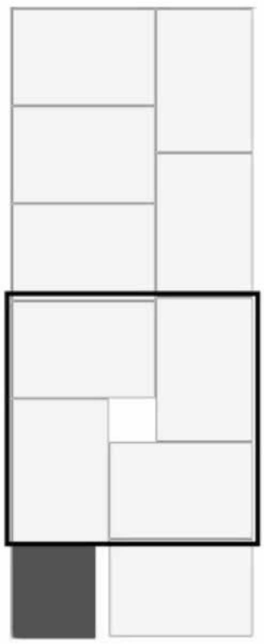

Figure 4. Loading system representation of an interlocking arrangement of boxes.

Figure 5. A loader's real-world representation of a loading plan using the same interlocking arrangement.

3.3 Use Case: Training aid

The system can be used as a training aid for teaching new or inexperienced loaders about loading and how to perform loading activities. Overall, the application of gamification principles and the manner of our approach has had a very positive effect on the use of the underlying loading system to which we applied the principles. The gamified system has increased, and continues to retain, user engagement and has provided a fun and engaging environment for performing serious loading tasks and activities.

4 Conclusion and Further Work

The majority of the studies on gamification tend to generally indicate a positive effect on the system that is gamified; this is however highly dependent on the context in which the gamification is applied, and on the users of the gamified system [16,17].

Our next steps will involve setting up a scoring system and implementing a high scores table into the interactive simulation.

As gamification is an ongoing process that should be constantly evolved over time to improve the nature of the interaction with users [18], much of this investigation will be focused upon continuous capture and analysis of data such as how easy it is to use the system, how effective the learning experience is, how much faster an inexperienced loader learns using the gamified system compared to the traditional means, how inexperienced loaders' performance in the gamified system compares to that of experienced loaders, how much performance obtained in the gamified system reflects actual real-world performance, and how much correlation there is between loading performance in the gamified system and loading performance in practice. This will help refine the user engagement process and ensure that the system has a direct impact on users, ultimately resulting in an increase in the performance of warehouse operatives in their day-to-day loading activities.

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References

[1] Deterding S, Nacke L, Dixon D, Khaled R. From Game Design Elements to Gamefulness: Defining "Gamification." Proc 2011 Annu Conf Ext Abstr Hum Factors Comput Syst - CHI EA '11 2011:9–15. doi:10.1145/1979742.1979575.

[2] Deterding S, Sicart M, Nacke L, O'Hara K, Dixon D. Gamification. using game-design elements in non-gaming contexts. Proc 2011 Annu Conf Ext Abstr Hum Factors Comput Syst - CHI EA '11 2011:2425–8. doi:10.1145/1979742.1979575.

[3] Black SE, Lynch LM. How to Compete: The Impact of Workplace Practices and Information Technology on Productivity. Rev Econ Stat 2001;83:434–45. doi:10.1162/00346530152480081.

[4] Brynjolfsson E, Hitt, Lorin M. Beyond Computation: Information Organizational Transformation and Business Performance. J Econ Perspect 2000; 14:23–48. doi:10.1257/jep.14.4.23.

[5] Debrabander B, Edstrom A. Successful Information System Development Projects. Manage Sci 1977; 24:191–9. doi:10.1287/mnsc.24.2.191.

[6] Majchrzak A, Klein KJ. Things are always more complicated than you think: an open systems approach to the organizational effects of computer automated technology. J Bus Psychol 1987; 2:27–50.

[7] Alcivar I, Abad AG. Design and evaluation of a gamified system for ERP training. Comput Human Behav 2016; 58:109–18. doi:10.1016/j.chb.2015.12.018.

[8] Remi-Omosowon A, Cant R, Langensiepen C. Hybridization and the Collaborative Combination of Algorithms. UKSim-AMSS 16th Int. Conf. Comput. Model. Simul., Cambridge, United Kingdom: 2014, p. 40–4. doi:10.1109/UKSim.2014.60.

[9] Remi-Omosowon A, Cant R, Langensiepen C. Deriving an Entropy Measure for 2D Container Layouts. IEEE UKSim-AMSS 17th Int. Conf. Comput. Model. Simulation, UKSim2015, Cambridge, United Kingdom: 2015, p. 103–8.

[10] Zichermann G, Cunningham C. Gamification By Design. 2008.

[11] Huotari K, Hamari J. Defining gamification: a service marketing perspective. Proceeding 16th Int Acad MindTrek Conf 2012:17–22.

[12] Werbach K, Hunter D. For the Win: How Game Thinking Can Revolutionize Your Business. Wharton Digital Press (October 30, 2012); 2012.

[13] Li W, Grossman T, Fitzmaurice G. GamiCAD: A gamified tutorial system for first time AutoCAD users. UIST'12 - Proc 25th Annu ACM Symp User Interface Softw Technol 2012:103–12. doi:10.1145/2380116.2380131.

[14] McDaniel R, Lindgren R, Friskics J. Using badges for shaping interactions in online learning environments. IEEE Int Prof Commun Conf 2012:12–5. doi:10.1109/IPCC.2012.6408619.

[15] de-Marcos L, Garcia-Lopez E, Garcia-Cabot A. On the Effectiveness of Game-like and Social Approaches in Learning: Comparing Educational Gaming, Gamification & Social Networking. Comput Educ 2015;95:99–113. doi:10.1016/j.compedu.2015.12.008.

[16] Hamari J, Koivisto J, Sarsa H. Does gamification work? – A literature review of empirical studies on gamification. Proc Annu Hawaii Int Conf Syst Sci 2014:3025–34.doi:10.1109/HICSS.2014.377.

[17] Groh F. Gamification: State of the Art Definition and Utilization. Res Trends Media Informatics 2012:39–46. doi:10.1145/1979742.1979575.

[18] Zichermann G. Designing Gamification Level 1. Online video clip. Udemy course, 2011. Udemy. Web: www.udemy.com/designinggamification- level-1-certification, 02 March 2016.