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Designing and Evaluating Gamified User Onboarding for an Industrial Simulation Tool

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Abstract

This thesis explores the potential of gamification to enhance the onboarding experience in a factory simulation tool designed for the corrugated fiber industry. The tool, developed for Van Den Bos Robotics, allows users to model transport systems and simulate production flows. While rich in functionality, the tool's complexity may pose a challenge for new users during onboarding. To address this issue, a gamified onboarding system was developed, incorporating game design elements such as missions, achievements, levels, and in-app rewards to guide users through key features of the tool.

Most gamification work focuses on employee performance and motivation; very little work is done on learning complex simulation software. This is a crucial gap provides a strong justification for the present study. By examining gamification in the context of digital tool onboarding, this thesis contributes new insights into improving learnability and user experience in industrial simulation environments.

To evaluate the impact of this approach, a between-subjects experiment was conducted with 16–20 participants of diverse academic backgrounds. One group used a traditional onboarding method (verbal intro and manual), while the other group experienced the gamified onboarding. Task performance, usability (SUS), engagement, and cognitive load (NASA-TLX) were measured and compared.

SAMMANFATTNING

Detta examensarbete undersöker potentialen hos spelifiering för att förbättra onboarding-upplevelsen i ett fabrikssimuleringsverktyg utvecklat för wellpappindustrin. Verktyget, framtaget för Van Den Bos Robotics, gör det möjligt för användare att modellera transportsystem och simulera produktionsflöden. Även om verktyget är funktionsrikt kan dess komplexitet innebära en utmaning för nya användare under onboardingprocessen. För att adressera detta problem utvecklades ett spelifierat onboardingsystem som innehåller speldesignelement såsom uppdrag, prestationer, nivåer och belöningar i applikationen för att vägleda användare genom verktygets centrala funktioner.

Majoriteten av forskningen kring spelifiering har fokuserat på anställdas prestationer och motivation; mycket lite arbete har gjorts kring inlärning av komplex simuleringsprogramvara. Detta utgör en betydande kunskapslucka som motiverar denna studie. Genom att undersöka spelifiering i samband med introduktionen av digitala verktyg bidrar denna avhandling med nya insikter kring hur lärbarhet och användarupplevelse kan förbättras i industriella simuleringsmiljöer.

För att utvärdera effekten av detta tillvägagångssätt genomfördes ett experiment med mellan-subjects-design där 16–20 deltagare med olika akademisk bakgrund deltog. Den ena gruppen använde en traditionell onboardingmetod (verbal introduktion och manual), medan den andra gruppen genomgick den spelifierade onboardingen. Uppgiftsprestanda, användbarhet (SUS), engagemang och kognitiv belastning (NASA-TLX) mättes och jämfördes.

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1 INTRODUCTION

Simulation tools are often used in industrial and academic contexts, however their complexity can lead to a steep learning curve for new users. Traditional user onboarding methods, such as manuals, formal training sessions, or brief verbal instructions, can be time-consuming, costly, cognitively demanding, and disengaging [6],[7]. These factors ultimately limit the effective adoption and use of such tools.

Gamification has been shown to increase engagement and motivation in various domains, such as employee onboarding, industrial work processes, and education [1],[2]. However, little research has explored the use of gamification in user onboarding, specifically in the context of onboarding new users to an industrial simulation software. Most of the available work on gamification in the industrial context focuses on increasing employee motivation or production efficiency, rather than teaching users how to use a specific tool. A notable exception is a paper by Kolbeinsson *et al.* [3], who utilised gamification to onboard users to a complex digital human modelling tool, finding improvements in engagement and perceived usability. This gap in the research presents an opportunity to explore whether gamification can improve usability, engagement, and decrease cognitive load when learning to use an industrial simulation tool.

The TransFORM app, which is an industrial simulation tool created by me for Van Den Bos Robotics, is a shopfloor layout tool that allows users to create layouts of factories for the corrugated fiber industry. A version of this tool with a gamified user onboarding introduction was developed, which contains features such as missions, progressive unlocking, progress bars, and a different style of UI. The gamified user onboarding was evaluated against the traditional user onboarding method, which involves more detailed verbal instruction and a user manual which explain how to use the original version of the app in a between-subjects experiment. Participants performed factory layout creation tasks, and their task performance, usability (SUS), engagement (UES), and cognitive load (NASA-TLX) were measured.

The objectives of this thesis are to investigate whether gamified user onboarding improves usability, engagement, and cognitive load compared to the traditional onboarding process, and to explore which gamification elements are the most effective in doing so. Ultimately, this thesis will contribute to the field of HCI by providing evidence of whether gamification can be successfully applied in such a context, and will provide insights regarding which gamification elements can enhance learnability and engagement in industrial simulation tools. These insights will aim to inform future designers and researchers on how to structure a gamified user onboarding for similar applications. With these aims and objectives in mind, the thesis will focus on the following research questions:

RQ1: Does gamified user onboarding improve usability, engagement, and task performance compared to the traditional onboarding process in an industrial simulation tool?

RQ2: Which specific gamification elements are most effective in supporting learnability and motivation in complex industrial simulation tools?

2 BACKGROUND

This section will provide an overview of typical user onboarding practices and will explain some examples of the different ways that gamification has been implemented in industry - specifically in user onboarding for industrial simulation tools. The section will also give a brief background of Van Den Bos Robotics, and will provide a description of what the purpose of the application created during this thesis is.

2.1 Onboarding

The term “onboarding” typically refers to the process of new employees joining and integrating successfully within a company [4]. The fields of HCI and User Experience have recently adopted this term to describe the process of a new user familiarising themselves with the basic functionality of a new software, app, or system. Samuel Hulick [5], in his book about the onboarding process, defines User Onboarding as the ”process of increasing the likelihood that new users become successful when adopting your product”.

Onboarding for simulation applications, especially more complex ones, usually involves a multi-faceted, but often suboptimal approach to familiarise users with the environment. Typically, when users are tasked with learning a new software, they would often be given a manual [6]. However, using manuals to learn an industry software can require high cognitive load [6], and require constant re-iterating to remain updated with the app itself. Additionally, companies can decide to create formal training sessions for their employees, which is especially common in software teams [7]. These formal training sessions normally take place in the form of instructor-led training, which is a training method where a knowledgeable instructor guides and facilitates the learning experience for individuals or groups, either in person or virtually, allowing for real-time interaction, questions, and immediate feedback, similar to a classroom setting. This is also not only time-consuming but can be costly if the software is provided by an external company and a representative is required to teach staff.

NetLogo is an example of a new application that only provides traditional user onboarding techniques. NetLogo, a free agent-based modelling software which was last updated in 2023, does not offer a step-by-step tutorial or overlay that engages the user - when a user encounters a difficulty, they are given the option of consulting their user manuals or video tutorials online, which do not interact with the app itself. Compared to a professional, feature-rich CAD software like AutoCAD, NetLogo presents a more specialized and contained set of functionalities. This relative simplicity of scope likely contributes to its user manual being a less daunting and more efficiently navigable resource for users seeking specific information or functional guidance. However, it is still important for apps such as this one to engage their users at least somewhat in the onboarding process so that ultimately, there is a higher likelihood they will learn the programme successfully.

As software has developed to be more user-friendly in recent years, companies have started to use first time hints, which are instructional pop-ups that guide new users through the basics of learning how to use a new software. Strahm et al. [8] observe that common onboarding tactics—like instructional text, timely hints, or interactive tutorials—are used in many applications to highlight benefits and boost user engagement. Yet, these choices often lack a solid methodological or theoretical basis [8]. While industry experts have attempted to set guidelines, these are typically developed without the benefit of generative user research or design theory, leading to a disconnect from how users actually learn and adapt to new technologies.

2.2 Van Den Bos and the TransFORM app:

Van Den Bos is a robotics company specializing in transport solutions for the corrugated fiber industry. Their core business involves designing and producing conveyors, transfer systems, and related equipment used to move materials efficiently between machines on the factory floor. As part of this, they are responsible for planning how material should flow through a production environment—determining the optimal number, placement, and configuration of conveyors to ensure smooth operations and avoid bottlenecks. Their work plays a crucial role in helping factories maintain high throughput and minimize downtime across different stages of the corrugated board manufacturing process.

Van Den Bos currently faces problems regarding serving customer demands. Currently, they use CAD (a design tool used to create detailed digital 3D models) to directly model the shopfloor and then calculate separately where in the transport system there might be bottlenecks. While CAD is good for visualising a layout in high detail, there is no feedback system, or any way of getting feedback regarding whether or not a layout is "correct". The software is hard to use, and has an overwhelming amount of options if the user wants to quickly create and simulate the functionality of the transport system. Furthermore, as each client has a unique set of demands and requirements, designing solutions for each request is labour intensive. To make this process easier, they decided to create a tool called TransForm.

In short, the purpose of this app is to make the workflow quicker by allowing employees to quickly put together a plan of a shop floor, and by decreasing the number of communication exchanges between other companies. Ideally, the app should be so easy to understand and use so that Van Den Bos employees can quickly make shopfloor layouts while meeting their customers, without requiring hours to do the model, then pitch it separately to customers.

Regarding the backend of the app, it will allow employees to calculate where there will be bottlenecks so that they can optimise the shopfloor to solve this digitally rather than waiting until an error happens in real life (Fraunhofer Innovation Platform), however, when designing the app, I was only concerned with the usability of the front end of the app, as another intern programmed the simulation aspect of the app.

2.3 The domain of corrugated fiber industry and transport solutions

The use of corrugated cardboard gained popularity around 1987. Reasons for this include its relatively low cost, and possibility of recycling the materials [9]. Corrugated fiber is used for packaging in industries ranging from food to pharmaceutical cosmetics, and due to this demand, the industry is expected to grow to 254.5 billion USD by 2026 [10]. According to an instruction manual by BET [11], a typical transportation system in the corrugated fiber industry consists of:

-Corrugators: Which are responsible for the production of the board

-**Conveyors:** Which serve to move the produced stacks around the factory

-**Transfer cars:** Which move the cardboard vertically, typically along intermediate storage areas

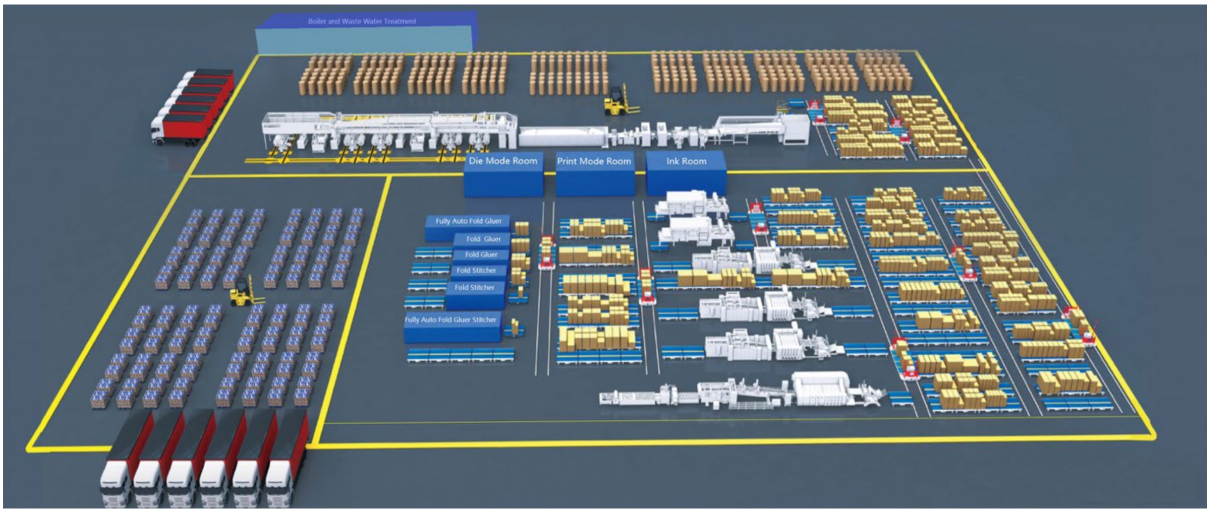
-**Intermediate storage areas (WIP):** This usually consists of a series of conveyors lined in parallel, and is used to store stacks of produced cardboard until the next step of the process

-**Material converters (machines):** These are large machines which edit the stacks somehow. Either they cut it, paint it, fold it etc.

-End of line (EOL): This is the final stage of the production process, and here cardboard is stored and gets ready for transportation

A lot of these components come in large number of variations, but to successfully run a simulation of a corrugated board factory, implementing all five of these are what is needed to create a successful MVP. As the conveyors and their connections are what Van Den Bos are mainly focused on editing and producing, it is important I focus more on these elements. **Figure 1** shows a typical layout of a corrugated fiber production factory, which features all of the components listed above.

Figure 1: Corrugated Fiber Factory



2.4 Gamification in Industry

Gamification refers to the use of game design elements in non-game contexts [12]. According to Karl Kapp [1], it is an emergent approach to instruction, and it facilitates learning and encourages motivation using game mechanics and game-based thinking. Examples of the non-game domains it is commonly applied to include work, productivity, marketing, and fitness [13] [14]. Regarding industry, Liu et al. [15] presented a gamified smartphone application for employees in the auto industry that tracks and provides real-time feedback on job performance, gamifying the work experience without altering the original tasks. Korn et al. [16] also explore the use of gamification in the automotive industry by presenting three designs that incorporate the "Visual Progress" game technique. This technique uses colour coding to indicate work process speeds: green for faster-than-normal processes, yellow/orange/red for slower-than-normal, and red for errors, with errors potentially triggering additional consequences like the removal of visual items. These projects showed how gamification can help keep employees engaged and motivated, and other projects have been done that have shown how gamification can help employees learn how to use a system. While gamification has been implemented in many industrial contexts, there is little work available online regarding gamification specifically in the field of learning a new simulation tool, as most focus on production techniques or tracking employee progress, to improve their retention and decrease required cognitive effort in the long run. When gamification is applied to learning a new simulation tool, it targets the unique challenge of mastering a more sophisticated digital environment for complex analytical or predictive tasks**.** This differs from gamification applied to production techniques (which focuses on optimizing physical/procedural behaviours) or general employee progress tracking (which focuses on broader skill development and performance metrics). The "learning" involved with a simulation tool is specifically about interacting with, understanding, and effectively utilizing a specialized piece of software to model and analyze complex systems. Numerous frameworks and models exist for game development [17], such as the six steps to gamification, the mechanics-dynamics-aesthetics (MDA) framework, and the octalysis-gamification framework. In addition, Geisthardrt [17] states that principles unrelated to gamification, such as design thinking, can also be used in game development creativity processes. This project will aim to implement concepts in accordance with these frameworks, mixed with taking inspiration from existing games, like tower defence games. Tower defence games, like Canyon Defence, are appropriate to take inspiration from as they are essentially about resource allocation and flow optimisation, an therefore could be easily applied to a tool that focuses on factory design.

2.5 Related Work

While gamification in employee onboarding has garnered significant research attention, providing valuable insights into motivational psychology and design principles, there remains a notable gap in the literature regarding its application to the onboarding process of software or applications, especially used in industry. Although "onboarding" serves as a broad term encompassing familiarization with any new system—be it an organizational environment or a digital tool—studies specifically addressing the gamification of learning a new software are far more pertinent to the objectives of this study, as they directly address the interactive and functional challenges of digital tool adoption.

Heimburger *et al*. [2] explore the use of gamification in employee onboarding by developing and evaluating a mobile onboarding application designed for generations Y and Z. Their study demonstrates that game-based features, for example QR-hunting, company quizzes, onboarding trees, and especially team bingo, can significantly enhance engagement, social integration, and perceived usability during the onboarding process. Notably, the gamified version of the app created for this study outperformed the non-gamified counterpart across multiple metrics, including perceived fun, intuitiveness, and motivation to engage before the first day of work. Furthermore, the study also uncovers correlations between personality traits (particularly agreeableness and openness) and a preference for gamified onboarding, suggesting that personalization based on user characteristics could further enhance outcomes and impact of gamification in a setting such as this. These findings provide a strong foundation for applying gamification strategies in other onboarding contexts, including digital tools and simulations aimed at training or familiarizing users with complex systems.

Ruiz, Orta, and Gutiérrez [18] propose a systematic gamification method to improve the onboarding process for new software engineers, addressing both the technical and human aspects of integration in an organisation. Their method includes defining onboarding objectives, mapping desired user behaviors to measurable actions, and implementing structured game mechanics such as points, badges, challenges, and progression levels. They emphasize user-centric design, enjoyment, and behavioral reinforcement through engagement loops, with a strong focus on customization and integration into workplace tools via platforms like GoRace. The approach is validated through an application case that breaks down onboarding into thematic areas, ranging from organizational culture and tooling to collaboration and problem-solving, and ties each to concrete gamified actions and metrics. This structured methodology highlights the importance of designing personalized, progressive, and feedback-driven gamified experiences to improve user motivation, learning, and performance. In the context of the factory simulation app that is the focus of this thesis, these insights are directly relevant: the onboarding design created adopts a similar progression-based structure, and incorporates visual achievements (e.g., races, quests, or levels) to reinforce continuous engagement during the process and leads to the user successfully learning the system.

The paper ″Gamification for Recruitment and Job Training: Model, Taxonomy, and Challenges″ by Obaid, Farooq, and Abid [19] presents a systematic literature review of gamified applications used for employee recruitment, engagement, and training. Covering 32 studies published between 2014 and 2019, it identifies trends, common gamification elements (like points, badges, and leaderboards), and their effectiveness in motivating users. The authors propose a taxonomy of game elements categorized by their function (achievement, reward, story, personalization, time, and micro-interactions), as well as a three-phase model for designing gamified applications (Define, Build, Assess Outcomes). They highlight key research gaps, including the overuse of simplistic elements, limited work on gamified recruitment compared to training, and a lack of attention to unmotivated users.

While the first two examples are relevant as they were used to inspire some of the gamification used in industrial contexts in general, a paper by Kolbeinsson *et al*. [3], titled "To What Extent is Gamification an Effective Tool for Onboarding Users into a DHM Tool", applies gamification to learning a software tool, which is what I set out to do in my thesis project, and is why I believe this paper is an invaluable resource for this thesis. This paper explores the use of gamification to support user onboarding in *IPS-IMMA*, a Digital Human Modelling tool used in industrial simulations. The study presents a first-stage evaluation of a gamified prototype designed to make learning the software more engaging and intuitive for new users. The authors emphasize that while gamification has seen increased interest in workplace and learning contexts, its design and evaluation in professional software remains underdeveloped. To address this, they conducted a heuristic evaluation of a gamified interface for IPS-IMMA, identifying key challenges and improvement areas, especially related to user motivation.

The gamification system they implemented includes four main modules:

- **Level module** (XP accumulation through use),
- **Mission module** (structured onboarding via tasks),
- **Achievements module** (badges for repeated or complex actions),
- **Shop module** (customizations unlocked with in-app currency).

Their findings stress that effective gamification must be user-centered, carefully designed with the users' motivations and tasks in mind. Poorly implemented game mechanics—such as shallow rewards—can reduce intrinsic motivation and lead to "gamification backlash." The study also underlines the need for more human-centered design and evaluation methods in CAD/CAM tools, which often overlook usability and user experience. This research contributes a rare case study of gamified onboarding for a complex engineering tool and provides practical design insights for future onboarding systems in similarly technical applications.

This chapter provided an overview of the process of onboarding and gave an introduction to the corrugated fiber industry. This chapter also provided some examples of gamification elements, explained in what context they have been applied, and showed that there has been research done that suggests gamification can have positive effects on user engagement and motivation. Additionally, the chapter also made clear what has inspired my design choices for the gamified version of the app.

3 METHODOLOGY

3.1 Research Design

This study uses a between-subjects experimental design to evaluate the impact of gamified onboarding on user performance for the TransFORM app. Participants are assigned randomly to either a control group which involves traditional onboarding, or an experimental group, which involves gamified onboarding. The aim is to measure and compare the experiences with both onboarding procedures across four key dimensions:

- Task performance (measured by time taken to complete tasks)
- Usability (measured by 10 question SUS survey)
- User engagement (measured by 12 question UES survey)
- Cognitive load (measured by 5 question NASA-TLX survey)
- Unstructured interviews and observations from usability tests

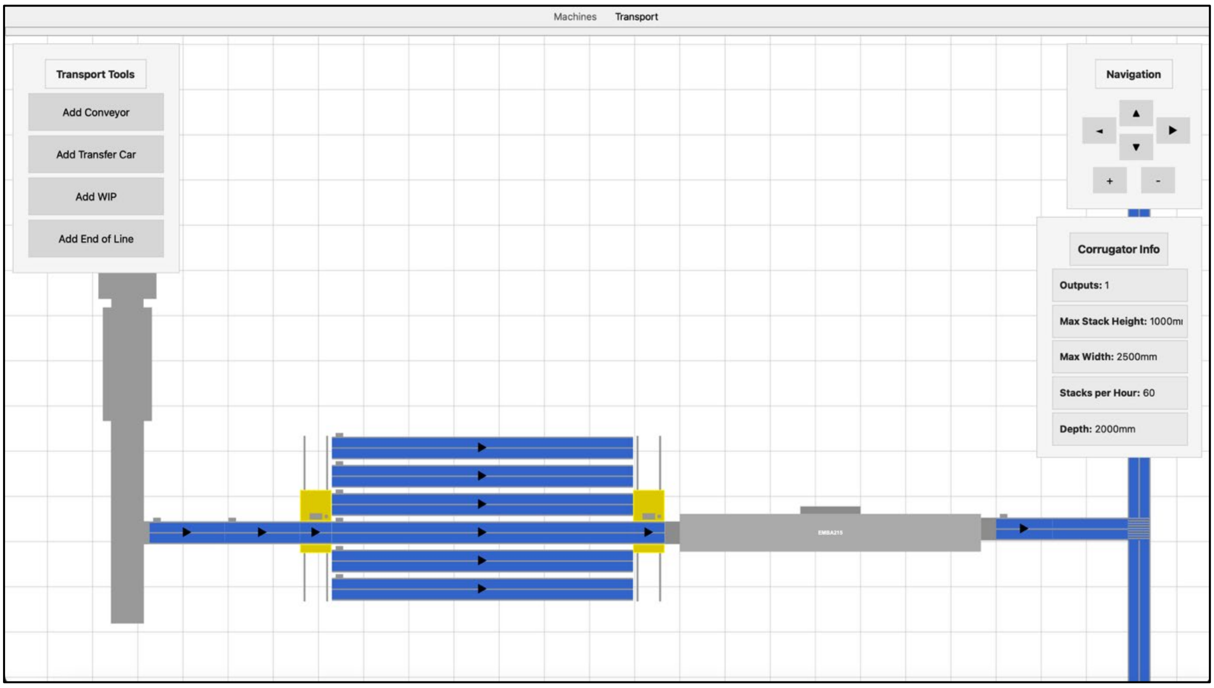
3.2 Original App Overview and Design Process

The original app, from now on be referred to as the "Industrial Version" was designed at Fraunhofer and Van Den Bos robotics. After the core functionalities and desires of the manager and employees were explained to me, I started to design wire-frames and mock-ups of how the app would look, and pitched them when they were finished. After feedback was given regarding them and the general structure of the app I conceptualised was finalised, I had weekly meetings with the company owner and manager who would review the progress and explain how he thought I should approach the next component. There would also be occasional meetings with the rest of the project team where employees working on other parts of the app would give feedback and pitch ideas. These meetings were useful because they outlined what the main features of such an app should be.

The app is designed to support real-time layout creation and editing, with visual feedback and snapping mechanisms to simulate realistic material flow. Users can freely place, move, connect, and configure these elements on a digital canvas. A simulation function validates the factory setup and identifies potential bottlenecks. **Figure 2** shows an example of a finished factory layout within the Industrial Version of the app. The app was designed entirely in Python, with elements of it being designed in Figma and Inkscape.

It should be noted that my role was focused on designing the app's core layout functionality as part of a minimum viable product. The simulation logic itself was developed by another intern, and the final version of the app was intended to be further refined and extended by a different employee after my internship concluded. My contributions were limited to the front-end features that allow users to create and configure factory layouts; the "Run Simulation" popup, which appears after layout completion, performs back-end calculations that do not impact the usability or onboarding experience being evaluated in this study. This was completed by another intern at the company.

Figure 2: original MVP for TransFORM



3.3 Gamified App Overview and Design Process

To test the effectiveness of gamified onboarding, a separate version of the app was created. This version will from now on be referred to as the "gamified version". The gamified version of the app has a slightly more gamified tone and layout, however the core functionality of the app (i.e. everything that occurs in the main canvas area) remains exactly the same. Keeping the core functionalities of both versions the same ensures that the differences in user experience could be attributed to the onboarding design rather than changes in features themselves. I completed extensive research on which gaming elements to incorporate, and frameworks to follow before the designing of the app commenced. The following paragraph summarises the different changes made in the gamified version and the rationale behind these changes.

To guide the design of the gamified onboarding experience in this study, I applied the Mechanics–Dynamics–Aesthetics (MDA) framework developed by Hunicke, LeBlanc, and Zubek [20]. This framework provides a structured lens for analyzing and designing game-like systems by separating the experience into three layers: *mechanics* (the concrete system components and rules), *dynamics* (the behavior that emerges through player interaction), and *aesthetics* (the emotional responses elicited in the user). In the context of the TransFORM app, this framework was particularly relevant because the onboarding process uses game design elements—such as missions, progress bars, and step-by-step checklists—to engage users and teach complex layout-building functionality. By designing onboarding mechanics that encourage task completion and feedback, I was able to create dynamics of exploration and progression, which were intended to evoke aesthetic experiences like satisfaction, clarity, and competence. As Hunicke et al. [20] note, MDA helps designers connect system design decisions to user experience outcomes by formalizing the way game artifacts are consumed and interacted with. This made MDA especially valuable for balancing usability with engagement in a simulation tool that is not inherently a game, but benefits from game-like structure and motivation during onboarding. **Table 1** explains each of the gamification elements in terms of the MDA framework.

Table 1: Gamified components explained in the context of the MDA framework

Mechanic	**Dynamic**	**Aesthetic**
Missions Hub that informs users what their next task is	Guides player behaviour by setting clear immediate goals	Evokes challenge and narrative
Progressive unlocking that only allows users to place an item once the item required for the new one to exist has been placed and modified correctly	Structures player learning and ensures that they understand one concept before moving onto the next	Evokes challenge and discovery through unlocking new features
Progress bar that fills in increments as the user gets closer to completing a full factory layout with all the required components placed correctly	Provides immediate feedback and visual motivation. It also helps to provide a sense of momentum	Evokes challenge and a sense of reward as the user gets closer to filling up the bar
Sound that plays when an item is placed onto the canvas. These include different factory construction or clicking sounds when items are placed	This reinforces correct actions, and provides a satisfying feedback, letting the user know the item has been successfully placed or "constructed" onto the shopfloor	This evokes sensation though auditory pleasure
A quick scaling **Animation** where the placed item seems to "appear" onto the screen from nothing	Reinforces the user that the item has been places correctly by providing quick feedback	Evokes sensation through visual pleasure

Redesigned toolbar styled like a tower defence game, with icons for objects instead of just text	This invites exploration and playfulness through familiar, game-like intercase	Evokes fantasy by mimicking tower defence games, expression by choosing and placing items, and challenge

Layout and tone- To support the onboarding goals of the gamified version, the app's layout and tone were intentionally adjusted to feel more approachable and game like. For example, small visual changes like rounded buttons and cleaner panel arrangements were made to reduce visual clutter and make the interface feel less technical. Regarding the layout of the component and toolbar buttons themselves, they were redesigned to mirror that of Canyon Defence, a tower defence game. Games like tower defence games are relevant as they focus on resource allocation and flow optimisation [21]. Tower defence games typically allow players drag and drop components (such as turrets or barriers) onto a grid to create an efficient defensive system. This similarity is relevant because both Canyon Defence and the TransFORM app require users to think spatially, plan sequential actions, and build interconnected systems over time. By borrowing layout conventions from a familiar game genre, the app provides a sense of structure and recognizability, helping users better understand how to place and connect elements to achieve their goals. This design choice was intended to ease cognitive load during onboarding by grounding the experience in familiar visual metaphors and interaction patterns. **Figure 3** shows this new layout.

Progress bar - According to Mazarakis & Bäuer [22] progress bars are not only easy to implement into a software, but also provide a means of summarising information. They can also be used to motivate users to complete a task and provide users with information about the partial success of their current objective. An animated progress bar was added on the top left of the gamified version, which would increase as correct elements are connected. For instance, adding the corrugator, which is the first element of a cardboard flow, would give 10%, then adding a conveyor to this would add another 10%. The flow would reach 100% once an EOL (The final component of a layout) is added and connected to everything else. Then, the user would be presented with a "run simulation" pop-up. The aim of this is to let users know they are on the right track to creating a finished layout of the factory, with all the corresponding components connected in the correct order.

Progressive Unlocking- Components will have a locked symbol until the user completes the previous step in the factory. For instance, the user cannot logically place a conveyor if there is nothing to connect it to. This will help users understand the design flow and logic of the corrugated fiber industry, and helps them understand that usually, the transport systems generally centre around the location of the corrugator. Additionally, you can't place an end of line until conveyors are placed, etc. The design process for different factories may differ, but generally remains the same, therefore, for the sake of the tutorial, we insist the user must place all of the components at least once before the layout is complete.

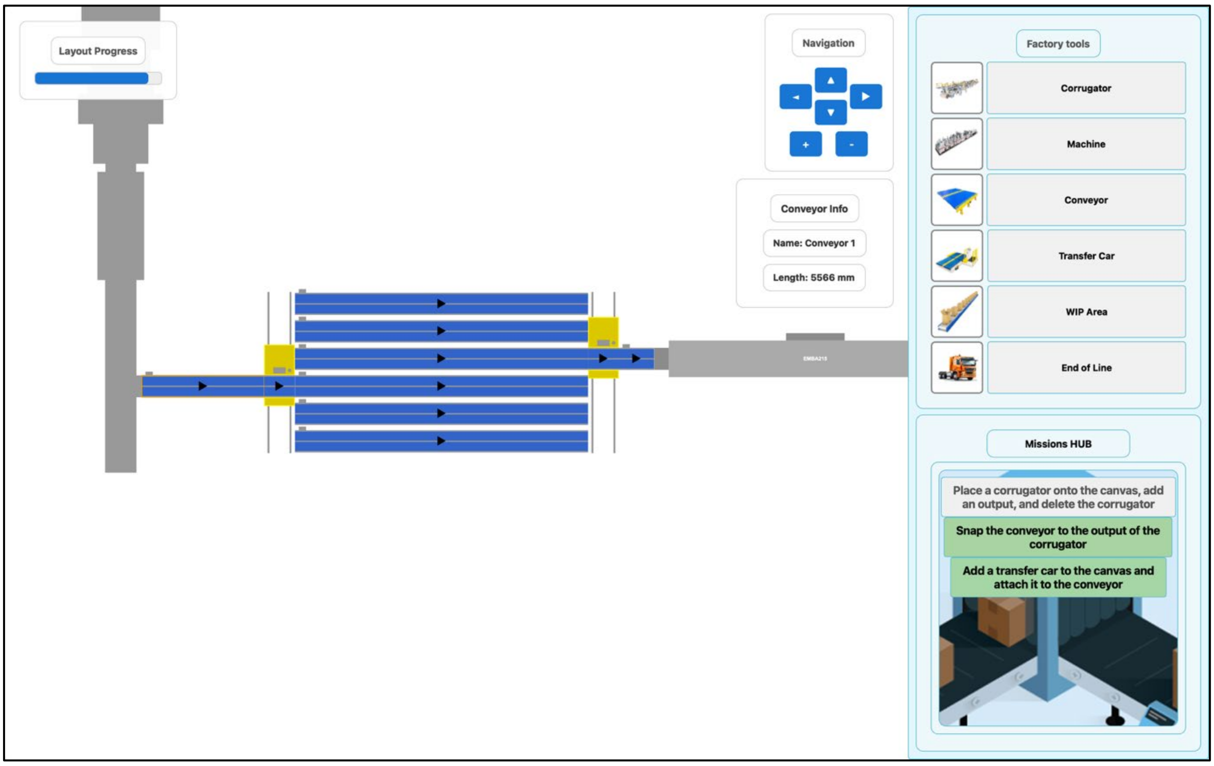
Mission HUB- Similar to the "mission module" which was designed to onboard users through tasks in the previously mentioned paper by Kolbeinsson *et al.* [3], the gamified onboarding for TransFORM features a missions hub. When the onboarding is started, the missions hub features one task: "Place one corrugator onto the canvas, add an output, and delete the corrugator". Once this is completed, the text box holding the mission turns green and the text in it is greyed out, and the new mission appears under it. These missions are designed to guide users through the creation of a factory layout, and to show them how different components can be modified.

Sound Effects- Sound effects are generally used to complement the visual feedback provided by components of gamified systems [23]. Some papers find that the Utilisation of Sound effects can harm the user experience if not used correctly, and warn that people should use them very sparingly [23]. A lot of games use sound effects as motivational feedback [24]. While there are a lot of ways sound can be implemented, the gamified TransFORM app makes use of simple clicking noises, to make adding, modifying, and connecting components more satisfying. Noises like these have been found to provide immediate confirmation of success, reinforcing correct interactions without requiring visual inspection [25]. Specifically, sounds were used for placing an item, modifying an item, connecting items, and finally, a truck sound is used to represent the End Of Line being Simulated.

Animations- When an item is placed onto the canvas, a scaling animation is triggered. This makes the component seem to "appear" out of nothing. This, in addition to the sound that is played, makes the process of adding a component feel more satisfying, and helps to draw attention to the component when it is placed.

Figure 1.1 shows the redesign with the gamified onboarding overlay, featuring all of the gamified components listed above.

Figure 3: Gamified User Interface



3.4 Experiment Design

This study employed a between-subjects experimental design to compare the effectiveness of two onboarding approaches for the TransFORM factory simulation app: a traditional onboarding method and a gamified onboarding experience. Participants were randomly assigned to one of two groups, each receiving a different onboarding treatment but performing the same set of tasks.

- Group A – Traditional Onboarding (Control Group):
  Participants received a 2–3 minute verbal introduction explaining the app's purpose and basic functionality. They were then provided with the non-gamified version of the app and a printed user manual for reference. While they were not required to read the manual in full, it was available to consult during task execution, both printed next to them and open on the computer in PDF document. The tasks were read to them after each previous task was completed.

- Group B – Gamified Onboarding (Experimental Group):
  Participants in this group received the same 2–3 minute verbal introduction, followed by access to the gamified version of the app. While the gamified version of the app was designed to be more self explanatory, and provided the tasks in the missions hub, I was still there in case they had any questions.

Both groups were asked to complete the same set of tasks, which were designed to introduce key features of the app. The tasks begin with simple tasks, such as to place a corrugator, add an output, and snap and adjust a conveyor to the output. Lastly, they are tasked with creating their own factory layout, that meets the needs of a minimum functioning layout, so that they get the “run simulation” pop-up on their screen.

To evaluate the outcomes, data was collected across five metrics:

- Task performance, measured by completion time for each task
- Usability, measured using the System Usability Scale (SUS),
- User engagement, measured with the short-form User Engagement Scale (UES),
- Cognitive load, assessed via a short-form version of the NASA Task Load Index (NASA-TLX).
- Unstructured interviews after the usability tests and observations made during the tests.

3.5 Survey Instruments

System Usability Scale (SUS) – The SUS scale is a simple 10 point questionnaire invented by John Brooke which is designed to give a view of the subjective assessment of the usability of a system [26]. The survey is scored from 0-100, where higher scores indicate a higher usability. The survey was chosen for this study because it is easy for participants to complete, and provides a standardizes benchmark for comparing usability between the traditional and gamified user onboarding methods. The survey asks participants to which extent they agree to certain statements such as "I imagine most people would learn to use this system very quickly" and "I needed to learn a lot of things before I could get along with the system".

NASA-TLX- This questionnaire was originally used by NASA to assess the cognitive load of a pilot, but has been modofied and applied to the field of HCI, beginning in 1994 [27]. The questionnaire aims to assess the mental demand, temporal demand, frustration, and effort that a participant goes through when completing a task. The results are scored out of 100, where higher scores indicate a higher mental effort required to complete a task. This survey was chosen so the mental demand for both onboarding procedures can be easily scored and compared. Questions in this survey that are especially relevant to this project include "How hard did you have to work to accomplish the tasks?" and "How successful do you think you were at completing the tasks?"

User Engagement Scale (UES) – This survey is used to capture the perceived usability of a system, and is also commonly used in HCI. The original survey consists of 31 questions, but is commonly adapted to cater to a specific system [28]. This project uses a short-form, 7 question survey, scored from 0-5, where a higher result indicated higher perceived usability. This was chosen for the experiment to easily score and compare the perceived usability of both onboarding procedures. Questions included in this survey that will provide an especially valuable insight regarding how engaged participants were in the experience include "I was absorbed in this experience" and "My experience was rewarding".

3.6 Participants

The experiment involved 16 participants with diverse academic backgrounds and varying levels of technological competence. Participants were primarily undergraduate and post-graduate students recruited from multiple disciplines, including design, engineering, and computer science. This heterogeneity was intentional to reflect a realistic cross-section of potential future users of the TransFORM app in an industrial setting - from my experience, people from a vast array of academic backgrounds can end up working in the corrugated fiber industry, including engineering, HCI, industrial design, mathematics, robotics etc.

4 RESULTS

4.1 Overview

This section presents the findings from the usability tests and surveys in groups A and B that are aimed to represent usability, engagement, and cognitive load. Results are reported across four key dimensions: task performance (time taken to complete each task), perceived usability (SUS questionnaire), cognitive load (NASA-TLX), and user engagement (User Engagement Scale). Regarding task performance, the mean-time taken to complete each task will be compared across both groups, and the mean total score for each of the surveys will be calculated and compared. The results suggest that the gamified onboarding has a higher perceived usability and engagement, and requires less cognitive load to use. Additionally, most of the tasks took considerably less time to complete for users in the gamified onboarding group.

4.2 Questionnaire results

Group A scored 72.8 on the SUS questionnaire, which indicates a slightly above average perceived usability for users - Generally, 68 is considered average for this questionnaire. Regarding cognitive load, the group scored an average of 23.75 on the NASA-TLX scale, which indicates that a relatively low mental effort was required for the users to complete the tasks. Lastly, participants in the A group reported a mean score of 3.67, which indicates that users that completed the tasks with the traditional onboarding process had moderately high levels of engagement.

Regarding group B, all of the survey scores saw a significant increase. Regarding perceived usability (SUS questionnaire) participants who used the software with the gamified onboarding reported a mean score of 89.4, which indicates excellent usability. Regarding cognitive load, participants scored 10.6 on the NASA-TLX survey, which is considered very low, indicating that users required very little cognitive effort to complete the tasks. Finally, regarding user engagement, participants reported a mean score of 4.25, which indicates a high to very high level of engagement. **Table 1.2** shows the mean score of all three questionnaires in groups A and B.

It is clear from the results that group A consistently outperformed group B.

Table 1.2: Mean scores of SUS, NASA-TLX, and UAE surveys across both groups. SUS and NASA are scored out of 100, and UAE is scored out of 5

Group A	Group B
SUS	**SUS**
72.81	89.4
NASA-TLX	**NASA-TLX**
23.75	10.6
UES	**UES**
3.67	4.25

4.3 Task performance

Participants in group A in general took more time to complete each task during the onboarding process than participants in group B, with the exception of the fourth task. For some tasks, the difference in the time taken to complete between both groups was not a considerable amount (for example tasks 2,5, and 4) however, tasks 1 and 3, which were designed to be the most demanding tasks, saw a large difference. For example, task 4 was to add a conveyor to the canvas, and modify it. Tasks like these involve interacting with multiple aspects of the system, like the machines tool panel, the object info panel, and the object properties panel. **Table 3** shows the mean time to complete each task compared across both groups

Task 6, which was to create a full factory layout using all of the components, took around a minute for each group. It should be noted that this task differs significantly from the other tasks in which there was a definite right or wrong answer. In this question, users needed to use some common sense, and had to apply all of the previously learned skills in one form or another. Both groups experimented a lot, and most participants came up with factory layouts that would make sense in real life and would be feasible to actually be created and implemented in a real factory.

Table 3: Mean time taken to complete each task for both groups

Task	Group A	Group B
Task 1	35 seconds	19 seconds
Task 2	11 seconds	10 seconds
Task 3	40 seconds	20 seconds
Task 4	4 seconds	5 seconds

Task 5	7 seconds	6 seconds
Task 6	69 seconds	63 seconds

4.4 Interviews and Observations

After the usability tests, a short, unstructured, interview was conducted with the participants. Three participants explained it was difficult to navigate the machine selection tool in the non-gamified version of the app, and that it felt somewhat "hidden". Three participants mentioned that it was unclear whether they had completed the given task successfully or not. One participant explained that the non-gamified version could have been more aesthetically pleasing, and another mentioned that they had wished for more micro feedback when interacting and placing components.

Regarding the gamified version of the app, four participants thought that the app was visually pleasing, and three participants said they found the feedback of completing a mission successfully satisfying. One participant mentioned they liked the sounds included when placing an object, and one participant said that it was too loud. Two participants said that the progressive unlocking made their experience with the app feel more "guided", but one participant said it was not initially clear at all that certain objects were locked or unlocked. One participant said that they liked the animations played when placing an object. Regarding the missions HUB, six participants said they liked how the missions were set out for them, and that it made the experience feel more game-like. However, one participant said that the background image included in the missions HUB confused them, and they initially thought it was meant to be something they would have to interact with. Two users explained that they did not even notice the progress bar on the top left.

While observing the participants usability tests, four of them had trouble navigating between the machine selection toolbars in the non-gamified version of the app. Regarding the gamified version of the app, a number of participants tried to select locked components. In addition, none of the eight participants mentioned or made use of the progress bar while using the gamified version of the app. It happened occasionally that participants would place an item on the canvas in the non-gamified version and try to place it again. Because the gamified version included both animations and sound, it was more clear to them if an item had been successfully placed onto the canvas, so this did not occur at all during usability tests with the gamified version.

5 DISCUSSION

5.1 Summary of findings

This study explored whether the implementation of a gamified onboarding process to a factory tool could lead to improved usability and engagement, a decrease in cognitive load, and faster task performance. According to the survey results, the gamified onboarding facilitated a more usable and engaging experience (measured by SUS and UES), and required less cognitive load from participants (measured by NASA-TLX). Additionally, participants who used the gamified onboarding took considerably less time to complete those more demanding tasks, which involved placing and modifying components. The amount of time taken to complete tasks which involved simple actions like moving an element in a certain place saw little difference between the two groups. The results regarding the time taken suggests that the benefits of the gamified onboarding are emphasized when users complete tasks that involve multi-step interactions.

5.2 Interpretation of results

The results of the usability tests and surveys support the hypothesis that gamified onboarding can improve usability and engagement, and lead to a reduced cognitive load if implemented in a virtual industrial simulation environment. Participants who used the version of the tool with the gamified onboarding overlay reported a more positive user experience and outperformed the other group regarding the time taken to complete each task.

One of the key factors contributing to the effectiveness of the gamified onboarding was the inclusion of the Missions Hub, which provided users with clear, step-by-step goals and immediate visual feedback upon completing each action. This was made clear from the interviews and observations. This helped users to understand whether they were on the right track, reducing uncertainty, and reinforcing correct behaviour. This constant feedback loop helped to make the learning process feel more satisfying and game like. While group A received the same missions as verbal instructions, these lacked ongoing feedback and structure during the task execution. Additionally, during the non-gamified onboarding process, a lot of participants were unsure whether the task was completed and continued to make changes to the component or explore the other options of the system.

Another component that significantly contributed to the effectiveness of the gamified onboarding was the re-designed interface to make the system seem more game-like and familiar. Because of this, all of the components were easily accessible, with corresponding clickable icons that visualized how the component would look like in real life. This was made clear from observing how participants used the app, and from the difference in the time taken to complete tasks that required users to interact with the toolbar. Participants in the gamified onboarding group did not have to navigate between separate tabs that featured their own category of information, which significantly contributed to the difference in time taken to complete tasks that involved navigating between these windows. Additionally, because this interface featured more colourful buttons, it was immediately more obvious quicker to users where buttons like the "delete" button are.

Sound was another component which contributed to the higher satisfaction of the gamified onboarding experience. Sound served not only to evoke the feeling of satisfaction, but to re-inforce that a correct action was completed correctly. Because of this, it was clear in the usability tests that participants were more aware that a component had been successfully added to the canvas or modified correctly as it drew their attention to the canvas and they spent less time in the toolbar trying to add something else, because they were unsure whether the task had been completed

Similar to sound, the animation added to components when they were placed on the canvas likely contributed to the increased rates of satisfaction reported in the survey, but also reinforced the fact that the item had been placed on the canvas correctly. It was clear from the usability tests that users were more drawn to the canvas visually when an item had been placed with the animation.

Progressive unlocking contributed to giving users a sense of direction and progress. This not only gave users a narrower amount of components that could be selected, but also led to them understanding why each component is added after the other. This understanding likely contributed in the less time taken for group B to complete the final task which involved utilizing everything the participants learned.

One component which was not really utilised was the progress bar. Originally designed to be of help with the final task, participants in group B did not make use of the progress bar at all. This was the only gamification feature that was overlooked and almost completely ignored. Perhaps the positioning of the progress bar (isolated on the top left) was a bit inconvenient.

In summary, all of the gamified components seemed to contribute to the higher satisfaction and quicker task performance in group B, with the exception of the progress bar.

5.3 Limitations

A major driver of the observed usability gains and faster task completion was the redesigned interface, particularly the toolbar, which was made more accessible and visually familiar. Unlike transient onboarding elements (e.g., the progress bar and Missions Hub) that can be introduced and later removed, the interface redesign is a persistent change. Reverting employees and other users to the previous, factory-style interface after onboarding would impose a second learning curve. Consequently, some of the measured benefits may stem not only from gamification mechanics but also from a sustained shift in interaction design. This confound limits our ability to attribute improvements solely to gamification and raises questions about how such elements should be integrated for long-term, production use.

Two design issues also surfaced. First, the "locked" state of components was not sufficiently obvious; several participants attempted to select unavailable items. A simple lock overlay would clarify the status of the component. Second, some participants clicked labels instead of icons, suggesting the need to expand hit areas and ensure consistent click-targets across icon–text pairs. Simply redesigning the text boxes to be smaller would also draw more attention to the related, selectable icon.

Additionally, although the Missions Hub delivered clear, step-by-step guidance in the gamified version, the control group received the same tasks verbally. In a typical onboarding procedure, this would usually not be done, however assigning missions gave an easy way to compare how easy it was to complete certain procedures in the app. This overlap may have partially narrowed differences between groups and should be controlled more strictly in future studies.

Regarding experiment design, the short exposure participants had to the system was an important limitation. The study measured only immediate outcomes during a single session, which captures first impressions but does not reveal whether the usability and engagement benefits of gamified onboarding persist over time. It remains unclear whether or not participants would retain the acquired skills, or whether these skills would transfer effectively to realistic work tasks in an industrial setting. While the experiment was completed with potential future users and not employees of companies who would be using the software in the long run, it becomes hard to implement a delayed post-test to paint a clearer picture of long-term learning and real-world applicability.

Additionally, the gamified version introduced several design changes at once, wheras the control version retained a more minimal, factory-style interface. This bundling of multiple elements makes it difficult to see which specific component – or combination of components – was responsible for the observed improvements in usability and engagement. As a result, it remains unclear whether the benefits were primarily due to the gamification mechanics themselves, the interface redesign, or simply the greater amount of feedback and guidance provided to the participants. In the future, these features could be isolated and tested seperately to better understand their individual contributions.

5.4 Future work

The findings of this study suggest that gamification has a strong potential to make user onboarding to an industrial simulation tool more engaging and effective. Other companies seeking to improve the adoption of internal tools could experiment with the types of features implemented in this project, such as mission based guidance, progress tracking, visual and audio feedback, and a different layout. By embedding these elements into their onboarding process, organisations may reduce the initial learning curve and foster greater motivation among employees. At the same time, future research and practice should examine how these mechanics perform in different organizational contexts, industries, and software systems, to better understand their generalizability and long-term impact.

As mentioned, the results of the experiments suggest that elements like the missions HUB, redesigned toolbar, and progressive unlocking can help to make the onboarding more engaging and thus can result in users learning to use the tool more effectively. However, future work could run A/B testing of each of these elements which turned out to be the most effective in this project to help clarify which of the features actually drive usability, engagement, and learning.

While the redesign of the toolbar contributed to a decrease in cognitive load, it does look a lot different than traditional shopfloor layout tools. Furthermore, as the app gets more feature heavy, it only makes sense for it to be designed as a typical similar app, with a number of drop down menus and editing options. It could be of value to try and find a “sweet spot” between a familiar, aesthetically pleasing app design, and a high functioning, industrial one. Achieving this balance would not only preserve the usability benefits observed in this study, but would also ensure that the tool remains scalable, efficient, and acceptable to professional users in production environments.

6 CONCLUSION

This project has focused on designing and evaluating a gamified onboarding process for an industrial shopfloor layout tool in the corrugated fiber industry. The thesis also provided a background of user onboarding, gamification in industry, and the corrugated fiber industry. The results of the between-subjects experiment conducted for the thesis suggest that implementing a gamified onboarding can lead to more engagement, higher usability, and less cognitive load than a traditional onboarding procedure. Furthermore, this project has put forward a list of which features of gamification have been the most effective in doing so, so that other researchers could implement these into their work.

Despite the limitations of the study, the findings of the study contribute to related research. For researchers, the study offers empirical evidence that gamified onboarding can meaningfully affect usability and engagement in complex systems, and points to specific areas where further investigation is needed. For practitioners, it demonstrates how gamification can be applied to industrial software to create a more approachable and motivating learning experience for employees. Ultimately, with a full gamified onboarding process or by implementing a few gamified features, user onboarding for industrial tools can shorten training time and reduce reliance on traditional onboarding methods such as manuals and training sessions.

If an app like TransFORM is more accessible, factories can become optimized faster, which can lead to a more quick and sustainable factory creation process. Ultimately, this change can lead to helping to cut material and energy waste if factories are optimized quicker before creation and implementation. Furthermore, if factory simulation apps are presented in a manner in which they are easier and more engaging to learn, there is less need on companies to rely on the time consuming and sometimes expensive traditional onboarding processes, such as user manuals and formal training sessions.

In conclusion, this thesis shows that while gamification is not a universal solution to creating a more effective and engaging user onboarding process, it does hold considerable promise as a design strategy for improving onboarding in industrial contexts. By carefully balancing usability, engagement, and functionality, future iterations of a gamified user-onboarding system could facilitate a more engaging onboarding process, and ultimately efficient tool adoption by employees.

REFERENCES

[1] Kapp, K. M. (2012). What is gamification. *The gamification of learning and instruction: game-based methods and strategies for training and education*, 1-23.

[2] Heimburger, L., Buchweitz, L., Gouveia, R., & Korn, O. (2020). Gamifying onboarding: How to increase both engagement and integration of new employees. *Advances in Social and Occupational Ergonomics: Proceedings of the AHFE 2019 International Conference on Social and Occupational Ergonomics, Washington DC, USA 10*. 3-14. https://link.springer.com/chapter/10.1007/978-3-030-20145-6_1

[3] Kolbeinsson, A., Palmquist, A., Lindblom, J., & Jiménez Sánchez, J. L. (2021). To What Extent is Gamification an Effective Tool for Onboarding Users into a DHM Tool. In *International Conference on Human-Computer Interaction.* 48-66. https://link.springer.com/chapter/10.1007/978-3-030-78221-4_4

[4] Gregory, P., Strode, D. E., Sharp, H., & Barroca, L. (2022). An onboarding model for integrating newcomers into agile project teams. *Information and Software Technology*, *143*, 106792. https://doi.org/10.1016/j.infsof.2021.106792

[5] Hulick, S. (2012). The Elements of User Onboarding.

[6] Gattullo, M., Scurati, G. W., Fiorentino, M., Uva, A. E., Ferrise, F., & Bordegoni, M. (2019). Towards augmented reality manuals for industry 4.0: A methodology. *Robotics and Computer-Integrated Manufacturing*, *56*, 276-286. https://doi.org/10.1016/j.rcim.2018.10.001

[7] Coppola, N. W., & Myre, R. (2002). Corporate software training: Is web-based training as effective as instructor-led training?. *IEEE Transactions on professional Communication*, *45*(3), 170-186. https://ieeexplore.ieee.org/abstract/document/1029957

[8] B. Strahm, C. M. Gray, and M. Vorvoreanu, “Generating mobile application onboarding insights through minimalist instruction,” DIS 2018 - Proceedings of the 2018 Designing Interactive Systems Conference, pp. 361–372, 2018. https://doi.org/10.1145/3196709.3196727

[9] Pereira, T., Neves, A. S. L., Silva, F. J. G., Godina, R., Morgado, L., & Pinto, G. F. L. (2020). Production process analysis and improvement of corrugated cardboard industry. *Procedia Manufacturing*, *51*, 1395-1402. https://doi.org/10.1016/j.promfg.2020.10.194

[10] Fitas, R., Schaffrath, H. J., & Schabel, S. (2023). A Review of Optimization for Corrugated Boards. *Sustainability*, *15*(21), 15588. https://doi.org/10.3390/su152115588

[11] Berufsgenossenschaft Energie Textil Elektro Medienerzeugnisse. (2010). *Safety requirements for transfer cars in the corrugated board industry* (BGI 854). Fachbereich Druck und Papierverarbeitung. https://www.arbeitsschutzdigital.de/ce/principle-design-rules-for-the-use-of-transfer-cars-in-the-corrugated-board-industry/detail.html

[12] Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011, September). From game design elements to gamefulness: defining" gamification". In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments* (pp. 9-15). https://doi.org/10.1145/2181037.2181040

[13] Woodcock, J., & Johnson, M. R. (2018). Gamification: What it is, and how to fight it. *The Sociological Review*, *66*(3), 542-558. https://doi.org/10.1177/0038026117728

[14] Sochor, R., Schenk, J., Fink, K., & Berger, J. (2021). Gamification in industrial shopfloor–development of a method for classification and selection of suitable game elements in diverse production and logistics environments. *Procedia CIRP*, *100*, 157-162. https://doi.org/10.1016/j.procir.2021.05.024

[15] Liu, M., Huang, Y., & Zhang, D. (2018). Gamification’s impact on manufacturing: enhancing job motivation, satisfaction and operational performance with smartphone-based gamified job design. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *28*(1), 38-51. http://dx.doi.org/10.1002/hfm.20723

[16] Korn, O., Muschick, P., & Schmidt, A. (2017). Gamification of production? A study on the acceptance of gamified work processes in the automotive industry. In W. J. Chung & C. S. Shin (Eds.), *Advances in affective and pleasurable design* (pp. 433-445). Cham: Springer. http://doi.org/10.1007/978-3-319-41661-8_42

[17] Geisthardt, M., Engel, L., & Schnegelberger, M. (2023). Towards Gamification of Advanced Value Stream Analysis and Design: A Game-Based Learning Concept. In *EnviroInfo 2023* (pp. 263-275). Gesellschaft für Informatik eV. 10.18420/env2023-024

[18] Ruiz, M., Orta, E., & Gutiérrez, J. (2024). A Gamification Method for Improving the Onboarding Process of Software Engineers. *IT Professional*, *26*(2), 67-75. 10.1109/MITP.2024.3374129

[19] Obaid, I., Farooq, M. S., & Abid, A. (2020). Gamification for recruitment and job training: model, taxonomy, and challenges. *IEEE Access*, *8*, 65164-65178. 10.1109/ACCESS.2020.2984178

[20] Hunicke, R., LeBlanc, M., & Zubek, R. (2004, July). MDA: A formal approach to game design and game research. In *Proceedings of the AAAI Workshop on Challenges in Game AI* (Vol. 4, No. 1, p. 1722). https://cdn.aaai.org/Workshops/2004/WS-04-04/WS04-04-001.pdf

[21] Brich, J., Rogers, K., Frommel, J., Weidhaas, M., Brückner, A., Mirabile, S., ... & Weber, M. (2017). LiverDefense: how to employ a tower defense game as a customisable research tool. *The Visual Computer*, *33*(4), 429-442. https://link.springer.com/article/10.1007/s00371-016-1314-0

[22] Mazarakis, A., & Bräuer, P. (2023). Gamification is working, but which one exactly? Results from an experiment with four game design elements. *International Journal of Human–Computer Interaction*, *39*(3), 612-627. https://doi.org/10.1080/10447318.2022.2041909

[23] Altmeyer, M., Hnatovskiy, V., Rogers, K., Lessel, P., & Nacke, L. E. (2022, April). Here comes no boom! the lack of sound feedback effects on performance and user experience in a gamified image classification task. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (pp. 1-14). https://doi.org/10.1145/3491102.3517581

[24] Ziemer, T., & Schultheis, H. (2021). The CURAT sonification game: Gamification for remote sonification evaluation. https://www.preprints.org/frontend/manuscript/637388f14363e789f29445173f156e26/download_pub

[25] Hancock, M. S., Shen, C., Forlines, C., & Ryall, K. (2005, May). Exploring non-speech auditory feedback at an interactive multi-user tabletop. In *Graphics Interface* (pp. 41-50). https://d1wqtxts1xzle7.cloudfront.net/3370190/Exploring_non-speech_auditory_feedback_at_an_interactive_multi-user_tabletop-libre.pdf?1390831505=&response-content-disposition=inline%3B+filename%3DExploring_non_speech_auditory_feedback_a.pdf&Expires=1755687783&Signature=FSJ1hjRCjZQwEcGRARxefpel0~WNVFcYlJCp8tvRAUXAsoz-JwOAdZvql~l5kLP2OIqAVNR439TIa4wjZLLakH8Nyf9pZ~3pUDKu1DgRT7sjnCk4CICG~hZdNneeB0UpZM2AMEl~7EG2ZEjJOa6~t6Xl5fjZXIt8qKEJ-qTreSTlpZ7cAkp527EtQI~bvNK2Yjtxf9oHUhbctKxbtvJ~c-qPLNGzISFcEeFLjBqWhHy4kgEMQuMelZHEUKHxl6QcK1hf66qrmHZbbBdXbvcpOqNH4-Yr6Of1BS1XjQTB3I~KM7Vvdjk3uHn7owx76Q4yTMTXjrl6q7YmnDmS5GALoQ__&Key-Pair-

Id=APKAJLOHF5GGSLRBV4ZA

[26] Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry*, *189*(194), 4-7. https://www.taylorfrancis.com/chapters/edit/10.1201/9781498710411-35/sus-quick-dirty-usability-scale-john-brooke

[27] Kosch, T., Karolus, J., Zagermann, J., Reiterer, H., Schmidt, A., & Woźniak, P. W. (2023). A survey on measuring cognitive workload in human-computer interaction. *ACM Computing Surveys*, *55*(13s), 1-39. https://doi.org/10.1145/3582272

[28] O'Brien, H. L., Cairns, P., & Hall, M. (2018). A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human-Computer Studies*, *112*, 28-39. https://doi.org/10.1016/j.ijhcs.2018.01.004

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