



Playful Reflection: Impact of Gamification on a Virtual Reality Simulation of Breastfeeding

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ABSTRACT

Gamification is a popular technique to improve task engagement, and has broadly been deployed in health and education to a point where many users now expect gameful experiences in these settings. However, gamification has been criticised for being a potential obstacle to the experience of reflection. Motivated by this tension, our work examines how the addition of gamification to a Virtual Reality simulation of breastfeeding impacts player experience and reflection. Using a within-subjects design, we invited 34 participants to take part in a mixed-methods evaluation of a gamified and non-gamified variant of the simulation that included questionnaires and semi-structured interviews. Results show that gamification improved player experience and encouraged players to reflect on goal achievement and performance. However, it also diverted players' attention from nuances within the act of nursing. Drawing on our findings, we contribute considerations for the application of gamification in personal and sensitive settings such as breastfeeding.

CCS CONCEPTS

- Human-centered computing → Human computer interaction (HCI).

KEYWORDS

Gamification, Reflection, Breastfeeding, Virtual Reality, Simulation

ACM Reference Format:

Kymeng Tang, Kathrin Gerling, Vero Vanden Abeele, Luc Geurts, and Maria Aufheimer. 2023. Playful Reflection: Impact of Gamification on a Virtual Reality Simulation of Breastfeeding. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23), April 23–28, 2023, Hamburg, Germany*. ACM, New York, NY, USA, 13 pages. <https://doi.org/10.1145/3544548.3580751>

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CHI '23, April 23–28, 2023, Hamburg, Germany

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<https://doi.org/10.1145/3544548.3580751>

1 INTRODUCTION

Gamification has received much attention from the research community due to its ability to engage users in tasks that are otherwise unappealing [21]. Despite nuances to its definitions, gamification is most widely referred to "*the use of game design elements in non-game context*" [14] to create a game-like experience, i.e., an experience imitating a rule-bound and goal-oriented form of play [63]. In healthcare and education, the implementation of gamification predominantly involves the introduction of performance and progress related elements (e.g., quests, points, badges, leaderboards) to engage and motivate users [21, 50]. However, researchers [5, 32, 33, 60] have criticised such approaches for being superficial because, in part, gamification diverts the audience's attention to the imposed challenges and goals rather than the core activity [5, 19, 60]. Here, prior work suggests that gamification, in some cases, engages users through extrinsic motivation that is supported by game elements, but at the same time, undermines users intrinsic motivation to engage in the core activity itself [8, 41]. In education settings, for instance, gamification can drive competition among pupils, incentivising them to complete learning tasks quickly, rather than paying attention to the correctness of their solution [19]. This suggests that game elements can be a source of distraction, hindering meaningful reflection on the core activity itself.

However, reflection is essential in many settings because it provokes thoughts and questions our initial assumptions about a matter, enabling us to view it from different perspectives, potentially leading to transformation of our thoughts or behaviours [3, 4, 15]. In healthcare settings, for example, games that confront players with thought-provoking situations experienced by healthcare workers prompted reflection on human error and the responsibility of caregivers within hospital environments [28]. Likewise, reflection on lived experience can also be leveraged to raise awareness of societal issues, for example, by using immersive systems such as Virtual Reality (VR) (e.g., see [10] and [2]). In a recent examination of VR to communicate the lived experience of early-stage breastfeeding [54], the authors found that an interactive simulation can spark reflection on breastfeeding both with respect to challenges and rewarding elements, but that many participants were keen to see more game elements integrated in the system. However, little is known about the interplay between gamification and reflection in sensitive and personal settings: would gamification distract users from the core of the activity comparable to what was observed in

settings such as education, or would gamification contribute to a more guided, and in turn more engaging experience?

In our work, we address this issue through a comparison of a gamified breastfeeding simulation with the initial, non-gamified simulation developed by Tang et al. [54]. To this end, we involved games researchers to carefully devise gamification strategies to augment the original simulation. The resulting system is a gamified VR breastfeeding simulation that draws from a subset of gamification elements: it provides users with feedback about their progress and performance using implicit audiovisual cues (e.g., elevated background music and particle effects) and explicit indicators (e.g., a progress bar, points, and badges). We leveraged both the original simulation and the gamified version (developed in this work) as research instruments to answer the following research questions:

RQ1: Is there a trade-off between player experience and reflection when introducing gamification in the breastfeeding simulation?

RQ2: Does gamification alter the perception that players have of the lived experience of breastfeeding?

Using a within-subjects study design with one independent variable (gamification), we invited 34 participants to take part in a mixed-methods evaluation consisting of questionnaires and semi-structured interviews. We examined player experience using the Player Experience Inventory (PXi) [1] and perceived workload using the NASA Task Load Index (NASA-TLX) [22] questionnaire. We also prompted for the experience of reflection using probing items that were rated on a 7-point Likert scale, administered in the context of a semi-structured interview. Results show that gamification generally improved player experience. However, we also show that it created an additional layer of reflection on goal achievement and performance, in some instances distracting players from appreciating nuances within the act of nursing a baby. Our data suggest that participants acknowledged that breastfeeding can be a physically and mentally demanding activity, but they noted that the simulation and its gamified variant highlighted a different set of core challenges associated with breastfeeding. Thus, gamification should be applied with care, considering that game elements direct player focus, and can therefore interfere with the original experience that is gamified.

Through this work, we make the following three main contributions: (1) We demonstrate that gamification impacts reflection in a simulation conveying the lived experience of breastfeeding, (2) we show that performance-based gamification in particular affected the way players approached our simulation, and (3) we provide a starting point for discussion on challenges and opportunities of the application of gamification in sensitive, personal settings like breastfeeding.

2 BACKGROUND

Here, we give a brief overview of gamification and its common implementation strategies. We also review related work on reflection and highlight its relation to gamification.

2.1 Gamification: A Brief Overview

Gamification is a technique used to increase the overall engagement, motivation and retention of activities that are otherwise

deemed as tedious [21]. Scholars came up with definitions to describe the practice, most notably, Deterding et al. [14], and Houtari and Hamari [26]. Deterding et al. [14] referred gamification to "*the use of game design elements in non-game context*". In their later work, the definition of gamification expanded to include conceptualising activities and contexts that affords gamefulness [13], i.e., an experience driven by challenge, fantasy, and curiosity [37]. From service marketing standpoint, Houtari and Hamari [26] defined gamification as "*a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes*". Here, the two views agree upon the notion that gamification entails creating a game-like experience, a design objective that harnesses the power of games in engaging players [48]. Early gamification literature theorised that gamification engages users through game elements that provide informational feedback (e.g., points, badges, progress indicators) as they address users' experience of competence, one of the main predictors of intrinsic motivation according to the Self-Determination Theory [48]. However, Mekler et al. [40] put this hypothesis to test in their study and found that gamification improves performance but does not necessarily address users' competence need satisfaction. This gave a rise to other theory-driven research that investigated the effect of gamification. For instance, the analysis of gamification through Goal-Setting theory by Landers et al. [35] and Hamari [20], and through the combination of Self-Determination theory and signalling theory [11]. While these pieces of research attempted to explain the effect of gamification, they also provide evidence supporting that gamification can improve productivity or engage certain demographics, especially those who have positive attitude towards games, through elements that support intrinsic and extrinsic motivation (e.g., performance and progress indicators). This potential has given a rise in the application of gamification in various settings, for example, in education [21], health care [12, 31], and business [34]. In a breastfeeding setting, prior HCI research [56, 62] has demonstrated that gamified breastfeeding education can be engaging for mothers-to-be and their partners. In the evaluation of a VR simulation addressing the lived experience of breastfeeding, a gameful experience is even an expected feature by participants [54, 56]. Despite the relevance of gamification in breastfeeding settings, prior research suggests that gamification can, in part, divert user attention, impacting users' experience of reflection on the core activity [5, 60] (more on section 2.4). Further, it is suggested by prior gamification literature [13, 21] that the effect of gamification also depends on the context of application and users. To the best of our knowledge, the impact of gamification on reflection has not yet been studied in literature that explored gameful systems in personal and sensitive settings like breastfeeding. To address this gap, we applied gamification to an existing breastfeeding simulation that has already demonstrated its potential in sparking reflection on the lived experience of breastfeeding [55] to investigate the impact of gamification on participants' experience of reflection.

2.2 Gamification in Practice

From the implementation perspective, gamification involves taking inspiration from games and applying those game elements or mechanics to existing activities. The more common approach involves

implementing feedback mechanisms and borrowing elements indicating task performance and progress such as points, badges, and leaderboard [14, 21, 50]. This approach has been criticised by the research community for being *shallow* as the emphasis is often placed on performance feedback and game elements, rather than user experience [13, 50, 57]. Other gamification approaches focus on incorporating social elements (such as likes or sending encouraging messages), or implementing elements that encourage curiosity and improve players' immersion, for example by means of adding audiovisual effects. A recent work of Hicks et al. [23] explored juicy design, a gamification implementation strategy that involves using an abundant amount of audiovisual effects to create a game-feel and visceral feeling [23, 24, 44], to complement the traditional points, badges, and leaderboard (PBL) implementation of gamification. The work suggests that juicy design can address some of the shortcomings of PBL by means of informing users about their achievements and making users feel connected to the activity. While there exist many approaches to gamification, the combination of the traditional gamification elements that focus on performance and progress (e.g., using PBL) and juicy design is particularly relevant for immersive and interactive simulations. This is because such systems already offer users the opportunity to be immersed in a separated reality governed by simulated rules, making them inherently playful, and hence, affording gameful design. This view satisfies the consideration of Deterding et al. [13] and Hamari [21] whom highlighted the importance of context and affordances when applying gamification on an activity. As such, we combined both the traditional approach to gamification and juicy design to gamify an existing VR breastfeeding simulation.

2.3 Reflection in HCI

Reflection has been an important design objective in many HCI studies [15]. Prior work has explored reflection as a means to give insights into ones' personal health data [6], support learning [46], and raise awareness about societal issues [2, 10]. Reflection is a suitable means for invoking thoughts about the practical barriers and challenges that breastfeeding parents encounter; it can encourage individuals to rethink how breastfeeding parents can be better supported. While many systems exist that considered reflection as a part of their design goals, literature reviews on reflection [3, 7, 15] underscore the vagueness of the term 'reflection' referred by HCI researchers. In an attempt to clarify the fuzziness of reflection across literature, Fleck and Fitzpatrick [15] grounded a framework for reflection, which postulates that reflection is an episode of thoughts that occurs through five consecutive stages starting from 1) *revisiting thoughts* being the lowest level of reflection to 2) *reflective description*, 3) *dialogic reflection*, 4) *transformative reflection*, and 5) *critical reflection* being the highest form. Resembling this approach, Baumer [3] defined reflection from three inter-related yet not successive dimensions consisting of surprising, uncertain and conflicting events that cause *breakdown* in the current paradigm and encourage *inquiries* which may involve *transformation* or fundamental change in one's thoughts. More recently, Bentvelzen et al. [7] built upon the work of Baumer [4] and surveyed literature that considered reflection as a design goal. The work provides four

design patterns for technology design to support reflection: temporal perspective, conversation, comparison, and discovery. Drawing from HCI literature that sought to reconcile reflection, we can argue that reflection involves revisiting thoughts that challenge the current individual's understanding of a subject, offering an incentive to view the subject from different perspectives and thereby, potentially leading to transformative thoughts or behaviours.

2.4 Reflection vs Gamefulness: an Unresolved Tension

Recently, researchers have started to acknowledge the role of reflection within the context of digital games. Khaled [32] drew from game design literature and criticised current approaches to serious games for providing elements that work against reflection, for instance, the provision of *safe environments* and *direct and solvable solutions* oversimplifies the complexity of real world situations, obscuring players' reflection and relatedness to the reality. In the qualitative inquiry of Mekler et al. [42], who studied players' experience of reflection through the framework of Fleck and Fitzpatrick [15], there was evidence suggesting that players reflected on their game play outside moments of play, however, the level of reflection was often limited to thoughts about game strategy with little to no reference to transformative and critical reflection (i.e., lacking wider implications in relation to the real world, necessary to change players' actions or behaviours). This finding is inline with Khaled's argument [32] that many games are designed around explicit feedback on in-game actions (e.g., points that quantify players' performance), hence, encouraging players to perform actions that contribute to the quantifiable performance rather than reflecting on the actions itself. Likewise, prior gamification research [5, 60] also criticised game-elements for distracting users from focusing on the core activities and their meaning. For example, Belim et al. [5] found in their work that sought to encourage pro-social behaviour among children using a gamified system that children optimised their behaviour just to earn extra points rather than reflecting on the meaning of their behaviours. This undesirable effect is the result of the lack of connection between the game elements and basic psychological needs (i.e., the need to feel autonomous, competent, and related) as explained through Self-determination Theory [47] in the work of van Roy and Zaman [60]. In spite of these criticisms, games have been touted as a vehicle for reflection [30]. In addition, the absence of game elements from platforms that are commonly used for entertainment purpose (e.g., VR) can lead to a mismatch in expectations, resulting in a hindered user experience and lowered enjoyment [53, 56]. While it is essential to have reflection in the context of breastfeeding, engagement might be a key strategy to involve different stakeholders beyond parents and parents-to-be in learning about breastfeeding [56], considering that the success of the individual breastfeeding journey depends on a collective effort [55]. This creates a tension between the need to provide an engaging experience and the provision of experiences that afford reflection, underscoring the under-explored area of reflection in player experience research [42] that we set to contribute through this work.

In the remainder of this paper, we will first describe the original VR breastfeeding simulation and the process of gamifying the

simulation. We then detail our within-subject design study with 34 participants to examine the impact of gamification on player experience and the experience of reflection. Here, we leveraged a mixed-methods study combining questionnaires and semi-structured interviews. Finally, we draw from our findings and reflect on the application of gamification in sensitive settings.

3 VIRTUAL REALITY SIMULATION OF BREASTFEEDING

A VR breastfeeding simulation described in [54] enables users to get a glimpse at the nursing process in three virtual environments, with and without the presence of (virtual) others. Designed with breastfeeding parents and their partners, parents-to-be, and health care professionals, the simulation aims to address the lived experience of breastfeeding, an aspect frequently overlooked by standard prenatal care [49].

In this work, we compare the original simulation and a gamified variant developed for this study, with respect to the player experience and reflection on the simulated breastfeeding experience. In this section, we provide a brief description of the original breastfeeding simulation in VR and detail the design process of the gamified variant.

3.1 Original Simulation

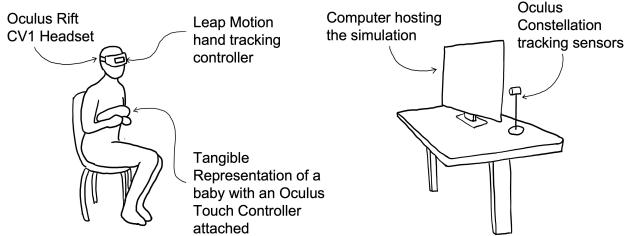


Figure 1: Technical setup of the VR breastfeeding simulation.

3.1.1 Technical Setup. The VR breastfeeding simulation leverages an Oculus Rift CV1 VR headset, a Leap Motion hand tracking controller, a doll representing a baby, and an Oculus Touch VR controller. Here, the Leap Motion controller is fixed on the front of the VR headset so that the user's hands can be tracked. The VR controller is attached to a doll (provided in two skin tones) so that the doll can be tracked in the virtual space and represented digitally. In terms of software platform, the VR simulation was developed with the Unity game engine using software development kits (SDK) from Oculus and Leap Motion.

3.1.2 Simulated Breastfeeding Experience. To simulate the experience of nursing a baby, the simulation provides virtual representations of the user and the baby that are mapped onto the pose of the user and the position of the tangible representation of the baby (i.e., a doll). Here, the upper-body pose of the user is estimated using the Forward And Backward Reaching Inverse Kinematics (FABRIK) based on the location of the VR headset and the user's hands. The position of the doll is tracked based on the attached Oculus Touch VR controller. In the virtual space, the user can use their hands

to directly interact with the virtual baby. This baby is animated to reflect the behavior of a newborn (see figure 2). This enables an approximation of breastfeeding interactions; the user can try latching and feeding the (virtual) baby by means of holding the doll and moving it close to their chest, mimicking the act of nursing.

3.1.3 Breastfeeding Settings. The original simulation [54] includes three breastfeeding settings: a personal living space, a public park and a workspace environment. Each setting was crafted to expose the user to different levels of social and environmental influence on parents' breastfeeding experience. For example, the personal living space setting provides a calm and private space to nurse whereas the workspace setting contains instances where the user is interrupted and requesting to leave the room (for a meeting) after three minutes by virtual co-workers.

3.2 Designing the Gamified Simulation

We involved researchers from the domain of games research (2), parenthood and technology (1), playful technology and tangible interactions (1) in a brainstorming session that sought to select relevant gamification elements suitable for the simulation. The session began with the main researcher introducing the original simulation and outlining its shortcomings discussed in prior work. Here, a summary of literature about the lived experience of breastfeeding and its associated challenges was provided to contextualise the breastfeeding experiences offered by the original simulation.

Next, all researchers were invited to view a walk-through video demonstrating the simulated breastfeeding experiences, and note breastfeeding events within the simulation that can be gamified. The notes were then shared and discussed among the brainstorming session attendees. A total of ten (breastfeeding) events that afford gamification were initially identified. This included: latching on time (i.e., before the baby starts crying), dealing with a painful latch, experiencing a peaceful latch (without pain), feeding, not-feeding (i.e., the state after the baby was unlatched or lost interest due to distraction), attempting to feed a distracted baby, rushing to latch and feed the baby (after a virtual co-worker imposed a time constraint to finish a feeding session), disrupting a painful feed, holding a baby who is fully fed, and failing to latch on time (baby starts crying). Through the discussion, the feeding and not-feeding event

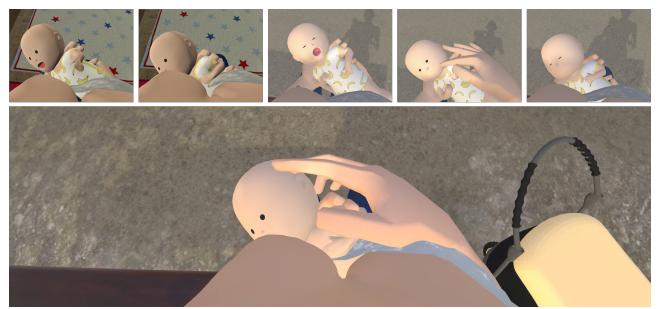


Figure 2: Simulated breastfeeding interaction and behaviors of the virtual baby: 1) trying to latch, 2) latched to the left breast, 3) crying, 4) being neutral, 5) sleeping and 6) being breastfed.



Figure 3: Breastfeeding settings of the original simulation in a personal living space, a public park and a meeting room in a workplace environment.

| Events | Gamification Elements |
|---------------------------------------|---|
| Latching on time | Bonus score Badge (First bite) Particle effect (Floating hearts) |
| Painful Latch | Begin decreasing score Flare effect Particle effect (Floating hearts) Vignette/damaging effect |
| Peaceful Latch | Begin increasing score Badge (Seeing the face of god) Particle effect (Floating hearts) Particle effect (Fireflies/fairy lights) |
| Feeding | Filling up progress bar Elevated background music |
| Disrupting a (painful) feed | Badge (Dare to disrupt) Particle effect (Sparkles) Pause score counter Draining progress bar Particle effect (Milk spillage) |
| Fully fed or failing to latch on time | Final game statistic screen Sound effect |

Table 1: Relationship between in game events and changes in the gamification elements.

Note: The static graphical user interface elements (points, progress and badges) are visible at all time, and this table only informs how and when they are updated.

were combined, the fully fed and failing to latch on time event were combined, and two events (rushing to latch, and attempting to feed a distracted baby) were deprioritized because there was agreement within the team that gamifying these events potentially imposed additional and overwhelming temporal demands on the player (e.g., pressuring the player to finish the feeding session within a short period). This resulted in a final list of six events/simulated states (see table 1) that guided our game element selection process.

We then identified game elements that could augment the existing simulation. We predominantly took into account gamification elements outlined in the literature reviews of Seaborn and Fels [50] and Hamari [21]. We also considered other prominent game design elements that are included in the original definition of gamification, including narration. Here, we weighed pros and cons of the different elements with respect to their impact on the breastfeeding simulation, i.e., the extent to which each elements would disrupt

or support the realistic depiction of breastfeeding. This resulted in exclusion of some relevant game mechanics; for instance, narration was not included because it risks offering one specific storyline, leaving less room for players to provide their own interpretation. Diegetic feedback elements were also excluded because they were not in line with the style of game expected by participants in prior work [54]. In addition, they can be challenging to integrate coherently into the simulation of a first-person experience (see [45]), and add extra mental load for novice players [27], which is particularly relevant in our case where engagement with the simulation remains a one-off for the majority of players. Therefore, basic game elements were in favour because they could deliver a game-feel to the simulation without altering its original message. Moreover, they were inline with the style of game anticipated by participants in prior work [54]. The proposed game elements and mechanics are summarised in table 1.

The main researcher then drew the proposed game elements as conceptualised within the scope of the simulation. These drawings of proposed game elements were further discussed, refined, and finally sketched out (see figure 4). These final sketches were used to guide our implementation of gamification, incorporating them into the workspace setting of the original simulation (see figure 2). The resulting gamified simulation was informally screened by a former game designer, a game researcher and a breastfeeding educator, and revised in accordance with their feedback concerning acceptability, usability, and the number of audiovisual effects. Screenshots of the revised simulation are shown in figure 5.

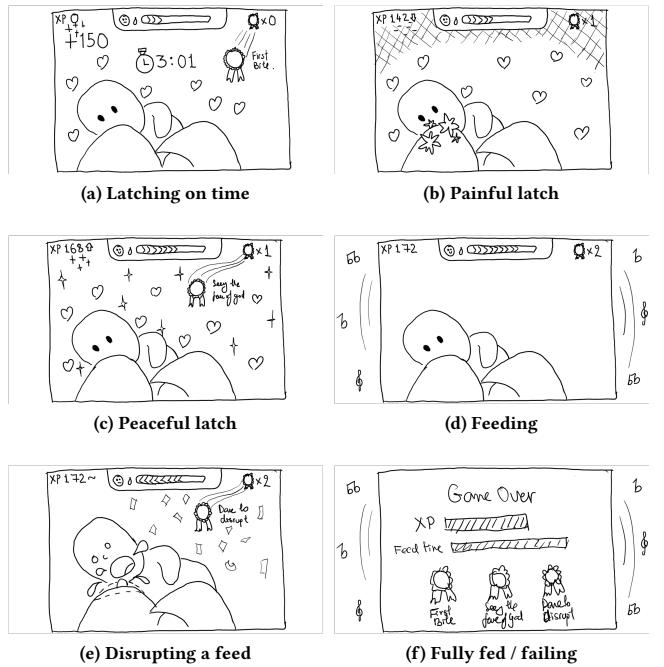


Figure 4: Sketched conceptualised gamification elements

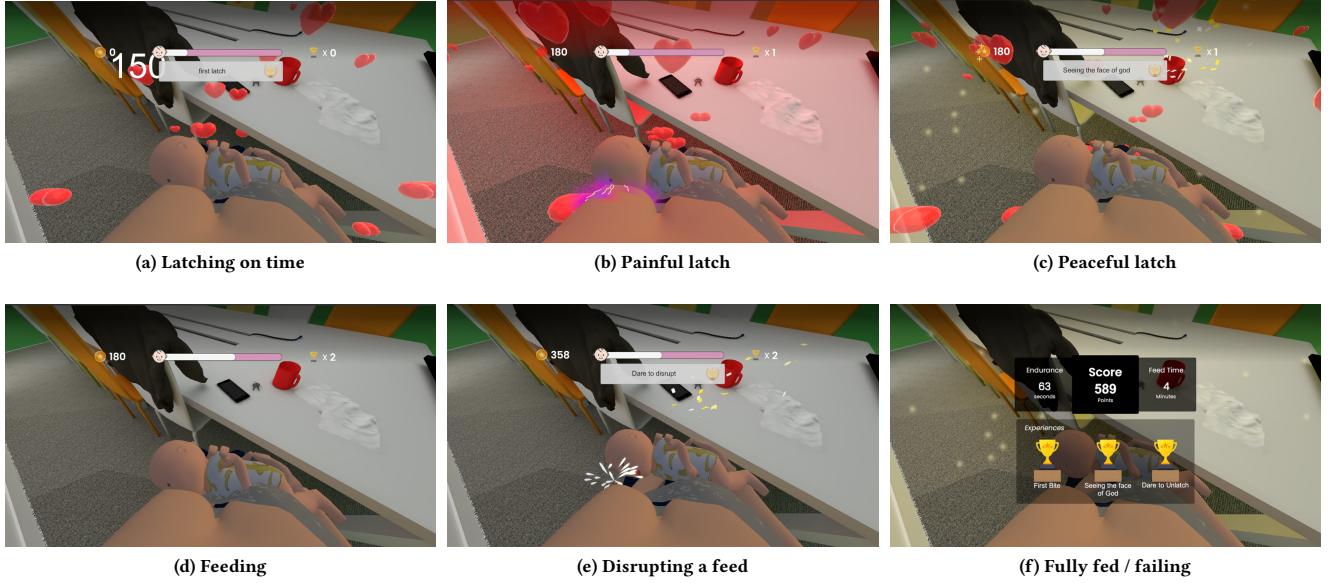


Figure 5: Screenshots of the gamified simulation

4 STUDY: IMPACT OF GAMIFICATION ON PLAYER EXPERIENCE AND REFLECTION

Motivated by the tension between the need to provide an engaging experience and an experience that can spark reflection, we conducted an experimental evaluation of the original simulation (a variant without game elements described in section 3 and in prior work [52, 54]), and the gamified VR breastfeeding variant (developed for this study). We compared the two variants (base and gamified condition) with respect to their impact on player experience and reflection on breastfeeding, using a within-subject study design with one variable (gamification). We applied a mixed-methods evaluation approach consisting of 1) standardised questionnaires and 2) probing items to be rated on a 7-point Likert scale deployed in the context of a semi-structured interviews. The objective was to evaluate the two conditions with respect to our research questions:

RQ1. Is there a trade-off between player experience and reflection when introducing gamification in the breastfeeding simulation?

Prior work suggests that gamification offers an effective way of improving user experience [21, 23] but at the same time distracts users from appreciating the core activities [5, 60]. Here, we hypothesise that:

H1a : Gamification improves player experience.

H1b : Gamification reduces the opportunity for reflection.

RQ2. Does gamification alter the perception that players have of the lived experience of breastfeeding?

Prior literature [16, 55, 65] provides evidence suggesting that uncertainty and vagueness are some of the core challenges of breastfeeding. On this basis, we formulated the following hypotheses:

H2a : Players perceive breastfeeding as easier in a gamified simulation rather than in its non-gamified counterpart because the gamified variant provides more performance feedback,

removing the uncertainty inherent in real-world breastfeeding.

H2b : Gamification emphasises player reward, and highlights that the success of caring for a (virtual) baby is meaningful.

4.1 Measures

We used two standardised questionnaires, the Player Experience Inventory (PXi) [1] and the NASA Task-Load Index (NASA-TLX) [22] to probe for player experience and perceived workload. PXI [1], an empirically validated survey instrument grounded on Means-End theory [18], and the Mechanic-Dynamic-Aesthetic game design and research framework [25], was designed to directly measure both the functional consequences (ease of control, progress feedback, audiovisual appeal, clarity of goals, challenge) and psychological consequences (i.e., higher-level constructs: mastery, curiosity, immersion, autonomy, and meaning) of game design. The instrument offers a reliable and theoretically sound approach to assess the immediate player experience and its relation to emotional responses. NASA-TLX is a widely adopted questionnaire for assessing perceived workload to perform a task. The questionnaire consists of six dimensions (Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration) to be rated on a 21 gradient scale ranging from very low workload (1) to very high workload (21). The NASA-TLX questionnaire helps us assess participants' workload and attention required to feed the virtual baby in each condition. In addition to evaluating the two conditions via questionnaires, we also administered four items in forms of a semi-structured interview to prompt for instances of reflection. In particular, we asked questions like "*To what extent do you agree that the simulation made you reflect on the act of breastfeeding?*", and "*To what extent do you agree that the simulation made you reflect on my performance as a player?*", which were to be rated on a 7-points

Likert scale. We then immediately followed up in qualitative exploration of participants' responses. We encouraged participants to revisit and reflect on their experience with the simulations using open-ended questions such as "*How would you describe the simulated experience?*", "*Are there any aspects you would like to get feedback on in terms of the act of breastfeeding?*", "*What are your thoughts about the game elements such as score, progress bar and badge in this simulation?*", and "*What was their impact on the experience that you had with the game?*". This is in line with best practices to examine reflection in the context of play, e.g., [29, 42]. We refer to supplementary material for the questionnaire items and a full list of questions.

4.2 Participants

We determined the minimum number of participants to recruit using a-priori power analysis, in which we assumed Cohen's effect size to be .5 and set the power ($1-\beta$) to .8 and significant level (α) to .05. With these, we can anticipate a 95% chance of correctly accepting the null hypothesis and a widely accepted 80% chance of correctly rejecting the null hypothesis. By setting the effect size to .5 (medium effect), we could constrain our test to be less sensitive to small (or negligible) differences between conditions. The power analysis yielded a minimum of 34 participants. We recruited a total of 38 participants through a snowball sampling method with posters distributed at university campuses, university events, classrooms, on social media, and through word-of-mouth between March 17, 2022, and May 19, 2022. We also wanted to control for a-priori engagement with breastfeeding and personal relevance, and therefore sought to only recruit participants for whom breastfeeding might become relevant in their future. This decision was motivated by the need to create a participant group that is representative and provides ecologically valid insights to study reflection. Therefore, we included an item asking participants about their plans to have a child. Consequently, out of the 38 participants, four participants were removed from our dataset as they had no plans to have a child or due to their age. Here, we would like to note that a demographic questionnaire item prompting whether an individual would like to have a child is sensitive and personal. However, we were transparent about the subject, and the prompting instrument (questionnaire) was screened by the institutional ethics board. Thus, we would argue that the question was appropriately deployed in the context of breastfeeding. Of the included 34 participants, 19 were female and 15 were male. Participants were in the age groups of 18-25 (20) and 26-35 (14). All participants resided in Western Europe but they grew up in Belgium (13), China (12), The Netherlands (2), Italy (1), Pakistan (1), Russia (1), Singapore (1), Spain (1), Turkey (1), and Vietnam (1). Twenty-three participants were in a relationship and 8 of them lived with their partner. None of the participants was a parent yet, and all of the included participants would like to have a child in the future (18 planned to have a child within the next 5 years). With respect to engagement with gaming activities, 32 participants played games on a regular basis, ranging from once a month to several times a day. Participants play games on a mobile phone (21), PC (19), console (14), and VR (7); 15 participants also engaged with non-digital board games and 2 participants suggested that they do not play any type of games. Participants

reported playing a wide range of video games including real-time strategy games (e.g., Civilization 6, Command and Conquer), role-playing games (e.g., Animal Crossing, World of Warcraft, GTA5), first-person-shooting games (e.g., Battlefield, Call of Duty, PUBG), and arcades (e.g., Candy Crush Sega, Super Mario, Subway Surfer).

4.3 Procedure

Participants were invited to take part in a 45 minutes within-subject study, in which they experience both the base and gamified condition. Participants gave consent via an online form and were asked to give consent verbally, at the beginning of the study session. At the start of the session, we supplied the participants with a brief background about the VR breastfeeding simulation, briefed that they will experience the two versions of a VR breastfeeding simulation, and how they can interact with the systems. Afterwards, participants were given the opportunity to ask questions. Here, we assumed that not every participant had experience with VR systems. Therefore, we provided a stripped down version of the simulation so that they could familiarise themselves with the simulation and understand the possible interactions with VR systems. This also helped us screen for motion sickness and minimise the impact of learning or novelty effects as participants had the opportunity to explore the possible interactions in VR beforehand. Next, we invited the participant to respond to a demographic survey, in which we asked for their familiarity with technology and games, and their family structure. Then, the participant was invited to experience the two conditions following one of the two sequences of a Latin Square Design in an effort to counterbalance order effects. Apart from the facilitator, no other researcher was present in the physical room.

Base Condition: Participants were invited to breastfeed in a virtual meeting space by means of holding a doll close to their chest, mimicking the act of nursing (see figure 1). Within the virtual space, participants could see a virtual representation of themselves and of the doll (see figure 2). Here, participants had to latch the virtual baby within a time frame of 30 seconds (undisclosed to the participants), otherwise, the baby would become agitated and start crying. There was a 40% chance that the virtual baby would not want to latch, hence, participants would need to try several times. Once latched, participants had to continue nursing the baby and avoid interruptions until the baby is full; this lasted around 3 minutes.

Gamified Condition: Participants were invited to follow the same procedure as in the base condition (i.e., nurse a virtual baby in a virtual meeting space). However, participants received more audiovisual cues about their performance and progress in this condition. Here, the 30 seconds time frame to latch the baby was indicated in forms of a progress bar (see figure 5); participants were rewarded with bonus points, received a badge, and were presented with heart particles upon the first successful latch. When latching the baby, there was a 50% chance that the latch is painful (see figure 5), to which participants could interrupt and reinitiate the latching process, or ignore the (pain) cues and continue nursing. As the participants continued feeding, the progress bar indicating the baby's fullness would get filled, and participants would lose or earn score depending on whether the latch was painful or not (for a complete

list of gamification mechanics, please see table 1). Upon completion of the nursing task, which lasted around 3 minutes, participants were presented with game stats summarising the points and badges they earned, and the time they spent nursing the baby.

After experiencing each condition, we invited the participant to respond to the PXI and NASA-TLX questionnaires, followed by a semi-structured interview concerning the experience of reflection, which we recorded and later transcribed. At the end of the study, participants were given the opportunity to ask questions or comment on the study. Here, they were reminded about their chance of winning one of the five 50 Euro gift cards or cash of the same value for their participation. Offering some form of compensation for study participation is best practice at our institution; the chosen approach was approved by the ethics committee. Study sessions were conducted in English and the research protocol was approved by the institutional ethics committee.

4.4 Data Analysis

We analysed our survey responses in Python using the pingouin package [58]. We provide descriptive statistics for constructs of the PXI, NASA-TLX and the initial probing items concerning reflection. We also report the results of paired sample t-test (p-value and Cohen's d as a measure of effect size), which indicate key differences between participant groups. Here, we characterise statistical significance between groups when p-value is less than .05. Qualitative data are provided to further explain quantitative findings.

4.5 Results

In line with our research questions, we present our quantitative findings supplemented with interview data.

RQ1: Is there a trade-off between player experience and reflection when introducing gamification in the breastfeeding simulation?

H1a: Gamification improves player experience. Results from the Player Experience Inventory (PXI - see table 2) generally support the notion that gamification can bring a positive impact to player experience, particularly with respect to the functional consequences. This suggests that gamification can directly improve the immediate experience with the simulation. Here, significant effects were found on many functional dimensions including Ease of Control, Clarity of Goals, Challenge (i.e., the extent that challenges in the game match the players' skill level), and especially Progress Feedback, all of which were rated higher in the gamified condition compared to the base condition.

In terms of psychological consequences (i.e., the second-order emotional experiences), the only significant difference is found in Immersion dimension, where the gamified condition scored slightly higher than the base condition. There was also a significant effect on the Enjoyment dimension, where the gamified condition was rated higher.

This is reflected in participants' comments such as "*the game elements also have their added values, to make it more of a fun experience, make it less boring.*" (P15), "*with this (game), it is just easier to know that you are doing well, because you know, you see, there are several meters, for how full the baby is, you score, the hearts when the baby*

| | | Standard Mean (SD) | Gamified Mean (SD) | Significance |
|---------------|-----------------------|--------------------------|--------------------------|-----------------------------------|
| Psychological | Meaning | 1.15 (1.353) | 1.11 (1.342) | t(101)=0.21, p=0.836 |
| | Curiosity | 1.2 (1.379) | 1.41 (1.239) | t(101)=-1.42, p=0.158 |
| | Mastery | 0.68 (1.560) | 0.77 (1.533) | t(101)=-0.44, p=0.664 |
| | Immersion* | 1.36 (1.601) | 1.96 (1.146) | t(101)=-3.59, p=0.001, d=0.43 |
| | Autonomy | 0.26 (1.656) | 0.27 (1.522) | t(101)=-0.05, p=0.963 |
| Functional | Ease of Control* | 0.83 (1.645) | 1.42 (1.431) | t(101)=-2.95, p=0.004, d=0.38 |
| | Clarity of Goals* | 1.47 (1.545) | 2.16 (0.915) | t(101)=-4.81, p<0.001, d=0.54 |
| | Challenge* | 0.53 (1.493) | 1.02 (1.244) | t(101)=-3.24, p=0.002, d=0.35 |
| | Audiovisual Appeal | 1.25 (1.200) | 1.36 (1.161) | t(101)=-0.76, p=0.447 |
| | Progress Feedback* | -1.05 (1.723) | 2.23 (0.928) | t(101)=-18.81, p<0.001, d=2.35 |
| | Enjoyment* | 0.83 (1.502) | 1.57 (1.142) | t(101)=-4.51, p<0.001, d=0.55 |

Table 2: Summary of the result of the Player Experience Inventory

* denotes statistical significance.

latches on. These are all cues that help the player understand that I'm doing a good job (P32) "*One thing I find really interesting is that sound feedback of drinking, which previous was not there, so now you can get more immersion that the baby is getting fed.*" (P3) and "*I was more motivated because I could see the score, so it was clear, and I could see the goal much easier. This time (game condition), it was not that difficult; for the simulation it was really difficult*" (P18). Generally, our results suggest that feedback provided by gamification has an immediate impact on player experience, i.e., surface level improvement, which is also theorised to contribute to an enjoyable experience [1].

H1b: Gamification reduces the opportunity for reflection. Generally, our quantitative data about the experience of reflection (see table 3) do not support this hypothesis, however, our qualitative data bring about more nuances to supplement this finding. The result of the item concerning the experience of reflection on breastfeeding shows no significant differences between the gamified and base condition. However, the gamified variant scored significantly higher than the base variant on the experience of reflection on performance (see table 3). Our qualitative data reveal that gamification can appear as a source of distraction. This is backed by instances of participants citing that "*I was more intrigued into the achievements and the scores, which were going up and the slider which is moving. As such, I was less focusing on the feeding process*" (P9), "*I focused more on how I can complete this game instead of making me reflect on my own behavior* (P22). However, the interview findings also show that the gamified

| | | Standard Mean (SD) | Gamified Mean (SD) | Significance |
|------------|-----------------------------|--------------------------|--------------------------|----------------------------------|
| NASA-TLX | Mental Demand | 7.7 (4.361) | 9.05 (5.191) | t(107)=-1.48, p=0.141 |
| | Physical Demand | 5.12 (3.930) | 6.27 (4.494) | t(109)=-1.43, p=0.156 |
| | Temporal Demand* | 6.14 (4.763) | 9.21 (5.080) | t(110)=-3.29, p=0.001, d=0.62 |
| | Performance | 7.79 (5.053) | 8.16 (4.773) | t(111)=-0.4, p=0.691 |
| | Effort* | 6.56 (3.746) | 8.73 (4.654) | t(105)=-2.7, p=0.008, d=0.51 |
| | Frustration | 7.95 (4.993) | 8.29 (5.384) | t(110)=-0.34, p=0.732 |
| Reflection | Reflection on Breastfeeding | 5.11 (1.187) | 4.79 (1.417) | t(37)=1.07, p=0.291 |
| | Reflection on Performance* | 3.61 (1.461) | 5.79 (1.173) | t(37)=-7.68, p<0.001, d=1.63 |
| | Perceived Challenge | 5.26 (1.551) | 5.47 (1.464) | t(37)=-0.7, p=0.49 |
| | Sense of Reward | 4.82 (1.636) | 5.05 (1.538) | t(37)=-0.62, p=0.539 |

Table 3: Summary of the result of the NASA-TLX and items concerning reflection

* denotes statistical significance.

variant brought other challenging aspects of breastfeeding to light. Here, there were many instances in which participants reflected on the physical burden of breastfeeding and the practicalities of feeding a child on demand, for example, participants noted "I've never considered the fact that it could be painful and I don't know the extent to which it can be painful and what are the downsides, especially for the baby, you wouldn't be able to breastfeed if it's painful for you, so you have to think about that." (P27), "When finally the baby started biting (latching) without pain, I was like, oh my god, it's actually that long to get there and my hands were difficult to move, and I was bored at some points as well" (P33), "It made me reflect on situations when I was not feel comfortable but want to breastfeed, ... the interruption, I felt more worried and stressed about it because I also saw the progress and I heard them saying that I did not have much time." (P30). Moreover, we observed instances of reflection in both the simulation and gamified variants, for example, participants highlighted that "I never thought that there might be distraction if I need to find a place to feed the baby and place is not very stable, because someone can interrupt" (P25), "it was really thought-provoking; imagine you have to feed the baby twice a day in a meeting room, which is quite annoying I guess, and people come in" (P26), "... but now, I really have to do it, and realise the urgency and the relevance of it, it's making me reflect more. I definitely, in the future, if I see news about it or I know if people need to breastfeed, I will definitely think about this game and try to accommodate or try to help them in any way that I can." (P16), "I now have to think twice when I see a mother breastfeeding. I will just let her be" (P40). Our qualitative data suggest that, while game elements can distract in some instances, they can still be

a viable vehicle for provoking meaningful thoughts about other (more-difficult-to-convey) challenges associated with breastfeeding.

RQ2: Does gamification alter the perception that players have of the lived experience of breastfeeding?

H2a: Players perceive breastfeeding as easier in a gamified simulation rather than in its non-gamified counterpart because the gamified variant provides more performance feedback, removing the uncertainty inherent in real-world breastfeeding. Our results suggest that participants perceived the simulated breastfeeding experience as more manageable in the gamified variant. However, their perception of the challenges associated with breastfeeding remained unchanged. The results of the PXI (see table 2) show that the gamified simulation was rated significantly higher than the standard simulation on Progress Feedback and Challenge dimension. This suggests that participants were more aware about their progress and that challenges in the gamified variant were perceived as better suited for their skill level. Likewise, our items concerning the experience of reflection (table 3) also highlights that participants reflected on their performance significantly more in the gamified variant. However, results of the NASA-TLX (see table 3) show that participants felt more pressed for time (Temporal Demand) and that they needed to invest in more effort to feed the virtual baby, suggesting that the gamified variant was not regarded as easier. Strikingly, there is no significant difference on the perception of breastfeeding being a challenging process between the two variants of simulation (see table 3). Our qualitative data suggest that performance feedback provided by gamification addressed the uncertainty of the simulated experience, but not in a way that it diminished thoughts about challenges. For example, participants commented that "*<In the base condition> I was less engaged, mentally less engaged, the instruction was not clear, the target was not clear and what you are doing was also not clear, it made me hard to focus on what I'm doing ... In real life, you don't have like the progress bar to know how much your baby still want to be fed, and I feel that in the real world you also get anxiety or stress to just imagine, when will it be over?*" (P20). Interestingly, there were instances in which participants suggesting that the addition of gamefulness made the simulated experience appear less serious despite being challenging. For instance, one participant noted "*I feel like now it's more like a game, ... you know that it will give you some tensions, stressful, but you know that it won't happen in the real life, ... in the first condition (base condition), you felt like it really could happen in real life*" (P12). In sum, our results do not fully support this hypothesis; performance and progress feedback addressed the vagueness within the feeding process and afforded gamefulness, but did not influence participants' perception of the challenges associated with breastfeeding.

H2b: Gamification emphasises player reward, and highlights that the success of caring for a (virtual) baby is meaningful. The results for this hypothesis are ambivalent, considering that there is no significant difference between the two conditions on both the perception of breastfeeding being a rewarding process (table 3) and the Meaning dimension of the PXI (table 2), yet our qualitative data highlight instances of rewarding experiences perceived by participants. Here, our qualitative data reveal that participants experienced the sense of rewarding differently in the base and the gamified condition. For example, participants expressed that "with

the game, it is rewarding because you see the progress bar, but it is really due to the game elements, it's not I felt it myself." (P15) and that "*<In the simulation> When the baby started drinking, I felt a sense of accomplishment ... for game, the rewarding is not from the breastfeeding itself but from the badges*" (P2). This suggests that gamification, in some cases, shifted user perception of the source of experiencing a sense of reward. However, one participant highlighted that the sense of rewarding from both the simulation and the game is intertwined because "*the point of the game is to get the baby to breastfeed, so you get a satisfaction of, okay, you are playing the game the right way but also, I mean, you kind of related like, oh, the baby is getting fed, so it's good, in that way there is also a satisfaction that you are doing the right thing for the baby*" (P17). Others suggested that the gamified variant drives competition (incentive to win), and hence, diminished the emotional aspect of breastfeeding. This is manifested through instances like "*It gave a feeling that you are playing a game and you have to win <laugh>*" (P35), and "*<in simulation condition> because of the emotional factors and the bond that I felt, I would like to feel it with my own child one day. ... when I would get points, I would focus on the game and on playing it, I don't think the emotional connection would be that strong*" (P36). Here, our data suggest that, while gamification emphasises reward, it does not address the core meaning from the process of nursing a baby.

5 DISCUSSION

Here, we summarise our key findings in line with our research questions. We reflect on our findings and outline consideration for the application of gamification in sensitive settings like breastfeeding.

RQ1: Is there a trade-off between player experience and reflection when introducing gamification in the breastfeeding simulation? Our results show that gamification improved the player experience, particularly, with respect to the functional dimensions of the PXI (Ease of Control, Clarity of Goals, Challenge, and Progress Feedback) suggesting that the selected game elements had an immediate impact on the participants' experience with the simulation. While our data indicate that participants reflected on their performance more in the gamified variant, we did not observe any strong evidence indicating a significant difference in overall reflection on breastfeeding between the two variants. This suggests that the enhanced player experience did not hinder the experience of reflection. Here, our qualitative data further support this finding and highlight that game elements can instead be leveraged to deliver provocative experiences (e.g., burden and pain), a potential trigger for transformative thoughts [3, 28, 38]. However, our findings also suggest that the inherent emphasis on goals and achievements of gamification can divert player attention, distracting from the core activity of nursing a child. While distraction from the burden of an activity and directed goals may be desirable in certain contexts, e.g., to increase overall enjoyment or to mask the unpleasantness of an activity, we would like to argue that they contradict the reality of breastfeeding and can potentially reinforce unrealistic expectations of the feeding process.

RQ2: Does gamification alter the perception that players have of the lived experience of breastfeeding? Our data do not provide evidence that gamification impacted participants' perception of the lived breastfeeding experience. However, the results of

the PXI suggest that the performance and progress feedback provided by gamification addressed the uncertainty and vagueness of the simulated nursing experience, which potentially risks glossing over the challenges experienced by many parents. In addition, our qualitative data show that the emphasis on rewards, achievements, and progress of the gamified variant could elicit a sense of satisfaction (upon accomplishing the goal), stress and tension imposed by game elements. However, the elicited emotions also stood on the way of quiet and intimate experiences of feeding a child. This suggests that the impact of gamification lies on the surface level, yet it potentially endangers the core meaning of breastfeeding. This notion is further supported by participants' comments that the gamefulness diminished the solemnity of the simulation and the experience of intimacy from nursing a child, echoing the risk of conveying an unrealistic reflection of the lived experience.

5.1 Deploying Gamification in Sensitive Settings

Our work provides an experimental evaluation of the application of gamification on a VR simulation seeking to convey the lived experience of breastfeeding, which can be regarded as a sensitive setting because it is an emotional (or even controversial) topic. Through this work, we investigated the impact of gamification on player experience and the experience of reflection on the act of breastfeeding. We observed that the addition of the gamification layer improved the overall player experience and did not seem to have a negative effect on reflection. In line with Mekler et al. [42], we argue that enjoyment and improved player experience from gamification might not be a desirable outcome for this setting as it potentially shifts reflection to performance instead of breastfeeding itself. Here, we reflect on this finding and outline two considerations when applying gamification in sensitive contexts.

5.1.1 Enjoyable Player Experience: Is Higher Always Better? Player experience is a complex phenomenon resulting from gameplay; it describes the quality of player-game interaction [64]. For many games, enjoyment is considered a positive player experience [51] and is therefore the centre of attention for game designers [39]. This is even reflected in many instruments measuring player experience; notably, the PXI quantifies dimensions of player experience that predict enjoyment [1]. While enjoyment is desirable for many games and gamified applications, it should not be used as the sole benchmark for quality of player experience. Here, games that confront players with discomfort (e.g., [9, 17]) are not necessarily bad in terms of player experience. However, they do not fit into the enjoyment-centric paradigm. Reflecting on our work, the original simulation is not considered inferior to the gamified variant because it could not deliver better Ease of Control, Clarity of Goal, Progress Feedback and other dimensions of the PXI. In fact, the player experience of the original simulation better reflects the reality of breastfeeding, which is *uncertain, not fun and not user-friendly* [55]. This does not imply that measuring player experience using enjoyment centric instruments is irrelevant for games that involve serious experiences. In contrast, we would like to encourage researchers and designers to use the instruments as a neutral tool and interpret the outcomes from the perspective of the intended experience. For games unintended to be fun, other qualitative measures (e.g., player observation, interview) should be considered to

gain nuanced insights into player experience [28] and to ensure that the low scores come from the right cause.

5.1.2 Reframing Game Elements in a Non-gameful Context. Our data suggest that game elements were effective in teasing out certain challenges of breastfeeding (e.g., pain and stress), and can also reinforce the feeling of being in a game world, which is not serious yet still performance-oriented. From the perspective of effectiveness, this seems to be a success story of gamification because we succeeded in delivering a gameful experience while improving enjoyment and other dimensions of player experience (see section 2.1 and 2.2). However, we would like to argue that the elicited game-feel is problematic in our case because the emphasis was placed on rewards, performance and progress, not on the act of breastfeeding a baby. One can argue that the simulation and its gamified variant shared the same goal: to satisfy a baby. However, there was evidence in our data suggesting that the elicited emotional experiences were different in both conditions.

Further, the gamefulness downplayed the seriousness of the simulated situation, and risked creating a superficial impression of breastfeeding. This provides yet another example of a situation in which the ethics of gamification need to be considered (see [59, 61]). Our work adds nuance to considerations by Deterding [13], who suggests that researchers and designers of gamification should support *the good life* through their work, i.e., addressing relevant societal issues. However, in sensitive settings, what constitutes an *individual good life* may conflict with the *collective good life*, posing an additional challenge for researchers and designers. Staying with the example of breastfeeding, increased and prolonged feeding rates are of course desirable from a public health perspective [66] and therefore should be promoted as the good life. However, parents have highly individual experiences of breastfeeding. For someone having gone through a traumatic delivery of their baby, or experiencing intense pain while breastfeeding, nursing their baby may neither be a positive, playful nor a desirable experience. Thus, technology in this space needs to recognize and effectively address this tension.

In this context, we want to highlight one area where there may be merit in the inclusion of game elements in our work, namely, their ability in conveying difficult-to-convey challenges associated with breastfeeding (e.g., pain and temporal demand). Here, game design elements should be applied with care, to serve as visual delegates, which can inflict non-visual perceptions (e.g., presence, pain) [43]. Thereby, the integration of game elements is leveraged to support the conveyance of a realistic lived experience rather than to create a game-feel within the simulation.

6 LIMITATIONS AND FUTURE WORK

There are a number of limitations of this work. First and foremost, we leveraged a limited set of gamification elements to augment the original breastfeeding simulation. We also addressed juicy design under the broad interpretation of gamification. Considering that the impact that gamification has on an activity depends on the choice of game elements and the context, our findings cannot provide a generalised implication for every game elements and context. Future work should investigate how different game elements play out in other sensitive settings. Second, while this paper revisited

and define the notion of reflection, we did not leverage any of the frameworks that address reflection (e.g., [3, 15]) to structure our inquiries. This is because we wanted to avoid actively guiding our participants through a reflection process with our inquiries (see more below). This limitation needs to be considered when interpreting our findings. Third, we introduced an extra challenge (i.e., pain indicator) to the simulation through the process of gamification. While the introduction of this challenge fits into the broad definition of gamification, it alters the experience by means of making an implicit process explicit. From the experimental perspective, such a practice challenged our ability to dissect the effect of gamification, particularly within the context of our work. Third, we would to acknowledge that our method for probing reflection has its limitations. Since reflection is a guided process [15], our post-experience survey and interview could not isolate whether the reflection is a direct result of the simulations or it is elicited by the interview. Fourth, our initial probing items were not validated as we did not intend to develop a survey instrument to assess the experience of reflection. It is generally known that reflection is difficult to reliably prompt (e.g., it depends on how well an individual can articulate their thoughts [42]). This challenged our ability to identify instances of reflection from the interview data as our participants were non-native English speakers. We encountered instances in which participants struggled to elaborate on their experience of reflection despite being fluent in English. Here, we encourage future work to leverage a combination of different methods (see [28]) to support the elicitation of nuanced experience of reflection.

Our work leveraged a within-subject study design to identify key differences in the experience of reflection on breastfeeding and performance using questionnaires and semi-structured interviews. We provided a simulation of breastfeeding in a challenging environment in both base and gamified condition to provoke thoughts about the influences of norm and environment on the feeding experience. Throughout our study sessions, we received comments from participants such as "*The novelty of it has worn off, everything happened the same without gamification elements*" (P26), suggesting the existence of *learning effect* in our study, and hence, influenced participants experience of reflection. Although we attempted to compensate for the *learning effect* (e.g., by providing a stripped down version of the simulation as a try-out and using Latin Square design), we believe that the effect might not be well isolated as using provocative experiences to trigger reflection is very prone to the *learning effect* [3]. However, the use of within subject design also help us mitigate the influences from individual differences [36]. Finally, our participants were predominately young and resided in Western Europe. Therefore, our findings should be interpreted with cautions provided that individuals' perception breastfeeding is heavily influenced by cultural norms and the society [55].

7 CONCLUSION

Gamification offers an attractive means of improving enjoyment of an activity, thereby engaging users. In this paper, we provide an experimental evaluation of the application of gamification to a Virtual Reality simulation addressing the lived experience of breastfeeding. Through this work, we examined the impact of gamification on player experience and reflection. Results of our work

show that gamification can contribute to an improved player experience, but that it does so while also introducing an additional level of performance-related reflection into the experience. The additional gamification layer creates a goal, achievement and performance oriented experience that distracts players from appreciating the act of nursing a baby, a shift that needs to be understood by designers of such experiences. Overall, our work provides a point for discussion on the application of gamification in sensitive settings, highlighting opportunities of the approach, but also outlining that the impact of specific gamification elements needs to be carefully examined before assuming that the core experience provided by the simulation remains unchanged.

ACKNOWLEDGMENTS

We would like to thank all participants of our research for the contribution of their time, and for sharing their perspectives on the simulations with us. We would also like to thank KU Leuven Campus Group T for funding this work through a PhD scholarship for the main author.

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