Live Learning Games: Insights from the application of a collaborative hybrid game environment for staff training

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Abstract. The Live Learning Game was designed as a ludic learning environment in the GamesLab at Hamburg University of Applied Sciences and prototyped for use in safety training. The system combines physical and digital game elements to create a collaborative learning experience. This paper evaluates and presents the findings from several application runs. The results suggest that the hybrid game application has at least a stimulating effect on the participants' motivation to learn and that content in particular can be well remembered due to the fun of playing and the positive team experience. In this context, it is important to link in a meaningful way the design of the game space, the narrative framework and, above all, the gameplay with the teaching content.

Keywords: Live Learning Game, Playful Learning, Game-based Learning, Hybrid Games, Collaborative Learning, Staff Training, Game Design.

1 Introduction: The Live Learning Game

In 2017, a large vehicle manufacturer contacted the GamesLab team at Hamburg University of Applied Sciences with the task of designing and prototyping a Live Escape Game to be used for internal safety training. We developed a modular system that abstracts the Live Escape game genre and allows it to deliver company-specific training content. To this end, we prototyped an open, mobile, flexible digital and physical game space for groups of 4-12 players. The content of the pilot project was safety training for fitters and office workers—but the system also allows for other content and target groups.

Digital Escape the Room games (e.g. "MOTAS" [1], "Crimson Room" [2], "The Room" [3]) and their real-world counterpart Live Escape Games, i.e. games in which groups of players try to escape from a physical puzzle room (e.g. "TeamEscape" [4], "Exit Ventures" [5]), have enjoyed great popularity since the early 2000s. In recent years, these games have also found their way into the professional environment. Following the game principles of Live Escape Games, we have developed a system that combines the features of physical Live Escape Rooms and digital learning games as a

hybrid collaborative game environment for use in training purposes: the Live Learning Game.

The concept behind this is not so much about an escape game principle where the players have to escape from a closed room, but more about creating a situation that promotes learning through play. This can make training units in a professional context and also at teaching institutions in the future more attractive and motivating. To achieve this, a number of ludic elements and principles are applied and linked to learning content. The Live Learning Game is not merely about enriching the content with typical game elements, i.e. gamifying the content in the sense of Deterding et al. [6]. Rather, the entire teaching unit should be designed as a collaborative game unit in the sense of the game-based learning approach [6] [7] [8] [9]. Based on the hypothesis that ludic elements increase the motivation of participants and have a positive impact on learning success [10] [11] [12], we explore the question of how the combination of digital and physical game elements enriches the players experiences and contributes to learning motivation.

This article consists of three parts. At first the academic research context, methodology and limitations are outlined. The second part presents the development and set-up of the Live Learning Game and the game mechanics used, and continues with the findings of the evaluation of the prototype application for staff training. The third part discusses our experiences and results with regard to future directions and leads to a summarising conclusion.

2 Context

This paper situates playful learning in a collaborative hybrid game environment for staff training. As the study presents a practical perspective and evaluation of the development and application of a pilot prototype combining physical and digital game elements for learning purposes it could inform the development of future educational hybrid games, as well as contribute to the broader discussion on effective interaction design for playful learning environments [13].

In this context, the paper enters the field of learning motivation in relation to non-traditional educational science [14] and psychology [15], especially in relation to video game engagement [10] and intrinsic human needs [16] [17] [18]. Playful and gamified learning [19] creates situations that promote learning through play [20] by applying a number of playful elements and principles in the Live Learning Game presented here and linking them to learning content. In a sense, playful learning represents an umbrella term that links the academic research fields of gamification [6], game-based learning [8] [21] [22] and serious games [7] [23] in the learning context. Gamification ties in with existing concepts and research in the field of human-computer interaction [24] and game studies [25] and is examined here primarily in relation to motivational effects from an educational psychology perspective [11] [12] [26] [27].

This allows offering participants training sessions they can complete in their own depth and pace using of the efficiency of "natural learning" [14]. Games have enormous potential to stimulate further tangential learning and to play a motivating and inspiring

role [28] [29] [30]. Tangential learning refers to the process by which people self-educate when presented with a topic in a context perceived stimulating [30]. For example, students who played Civilization III [31] and then learned about the historical background on their own performed better in history classes [21]. This process takes place voluntarily and proactively by exciting interest in a topic without detracting from the fun of the activity [30].

From a game design perspective, incentives for tangential learning can generally be created in two ways: firstly, the learning content that is most fun can be wrapped directly into parts of the game and be acquired without any interruption of the game flow. Secondly, references to the learning content can be integrated into the game world and the players' interaction with it, and background knowledge can be offered over external links [32]. In this sense, the learning content itself can become a reward that can be unlocked through playing assiduously and is given a positive connotation correspondingly. This breaks with a previous paradigm of conventional educational games which reward the successful completion of educational content with more gameplay. The problem with the tangential learning model by Portnow & Floyd [30] is that no additional feedback or assistance can be given to the learners [29].

The main challenge of game design for playful learning applications is linking gameplay and the teaching content in a meaningful way [33]. Research fields such as narrative design (linguistics) [34], user experience and interface design (human-computer interaction) [35] as well as related areas such as gameplay flow (psychology) [32] [36] [37] and immersion (cognitive science) [38] also play a decisive role.

In application of the prototype the empirical methodology of the evaluation as well as limitations are described in the following section.

3 Methodology & limitations

Based on the hypothesis that ludic elements increase the motivation of participants and in turn have a positive impact on learning success [10] [11] [12], a combined quantitative and qualitative empirical evaluation was conducted to find starting points for the extent to which the combination of digital and physical game elements enriches the players experiences and contributes to learning motivation. In doing so, an investigation was conducted into how the playful approach supports understanding and remembering content. Since the case studied was a safety training application, we also wanted to examine whether the awareness of hazardous situations is raised and the motivation to adopt safety-conscious behaviour is enhanced.

Our premise was that particularly rewarding social interactions increase motivation and thereby learning success [10]. Accordingly we aimed to find out whether the participants had fun and how the team experience was perceived. Furthermore, the inclusion of narrative elements (game fiction) can also have a positive effect [12]. Consequently, we investigated whether the players found the story coherent. In addition to assessing the overall impression, we were also interested what the participants believed went well and where they saw room for improvement in a qualitative explorative feedback panel with the participants.

The explorative qualitative research was conducted on the basis of the grounded theory with the further progression of Gioia [39] [40]. The findings were structured using the inductive method of qualitative content analysis [41]. The evaluation can be positioned in the broad academic field of social sciences with regard to the quantitative investigation and descriptive statistical evaluation by means of questionnaires, and in the field of humanities with regard to the qualitative explorative feedback round. The disciplinary perspective is from the viewpoint of Game Studies with a special focus on Design & Development Researchs including Playful Learning discourses.

The current study refers to a client-specific health & safety training in Germany. Other fields of application such as schools or universities were not part of the study. Accordingly the special characteristics of the socialisation of children and adolescents are left out. Likewise, cultural aspects and differences are not taken into account in the present study. Conducting a larger-scale study with a more diverse sample would likely ensure that the results are generalisable to a wider population. Nevertheless, the results provide a comprehensive insight into the specific field of application in staff training.

Another limitation is presented by the fact that no classical learning objective assessment was carried out. The study focuses on the participants' opinion and self-evaluation. For these reasons, no before-and-after comparison as an objective knowledge assessment was carried out in this first approach. A direct comparison with traditional non-game teaching methods such as frontal presentation [20] [23] and the inclusion of a control group could broaden the understanding of the effectiveness of the Live Learning Game in follow-up studies.

4 Development: The hybrid digital-physical game environment

We developed a hybrid digital-physical game environment that opens up the Live Escape game genre to (in our case company-specific) training content. In this chapter we will present the modular room concept, the technologies used and the game design for the three team-based game phases.

4.1 Technical room concept: A flexibly adaptable play room with "magical" technology

The first concept for the Live Learning Game proposed a structure that was as flexible as possible, consisting of a room cube and partition walls as core elements. At later stages, the room cube was modified into a container or a fixed installation. Since it had to be possible to transport our prototype by plane, we initially chose lightweight folding furniture, free-standing walls and a modular frame system. The room is designed for the flexible use of 1-2 screens or canvases. Small and large-format posters displaying information and puzzle elements were mounted on movable walls or suspension systems, for example graphics and photos that participants had to find and match in games. In addition to digital surfaces, hard-copy posters and printed strips of fabric provide a flexible and inexpensive method of displaying content and exploiting different information channels. At the same time, these "strips" function as walls in the room. The

system therefore allows for the representation of different types of rooms, ranging from open to closed (Figures 1 & 2).

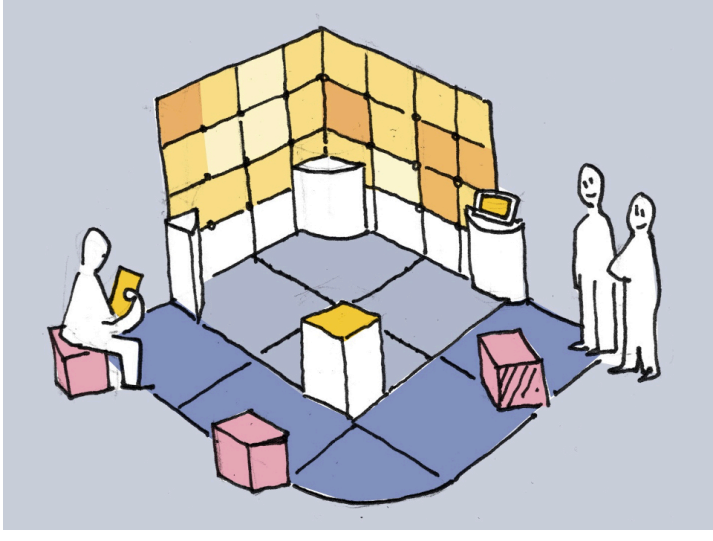

Fig. 1. *Early design of an "abstract" Live Learning Game game space open on two sides. The two rear sides are projection screens, monitors or supporting walls for posters. Pedestals serve as storage for game pieces and two tablets. Variable floor elements and small items of furniture connect the game with the environment. The system can be set up free-standing or in the corner of a room.*

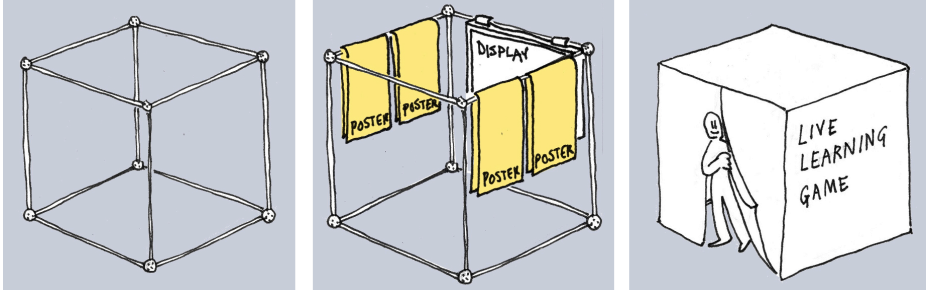

Fig. 2. *The flexible room and display system facilitates the use of different types of room. Existing walls, for example in a conference room, can also be used.*

The heart of the system was formed by a Windows PC (with OS Windows 8/10) running our Unity-based host game software and a dedicated Wi-Fi router for the communication with peripheral devices: two iPads (model 2017 with iOS 11 and ARKit 2) with client apps, communicating with the Unity host app, and two pointers sending sensor feedback via WLAN to the host application. The iPad client software used the

Unity plugin “ARKit XR Plugin” to implement AR functionality and thus the detection of several images hidden on posters and throughout the room.

The pointers were early prototypes consisting of RFID near-field sensors (RFID-RC522 module) and a WLAN interface (Wemos D1 Mini ESP8266 WLAN). Additionally, several stepping mats were connected to the PC via an iPAC 2 USB control interface. Information was displayed on a large central monitor and on printed posters. Our set-up was designed for two teams, each of which was given an iPad and a pointer. The joint game action was monitored by both teams on the large monitor. Sounds were played through a central loudspeaker.

The rounds in the game were supervised and moderated by a human game leader (Figure 3).

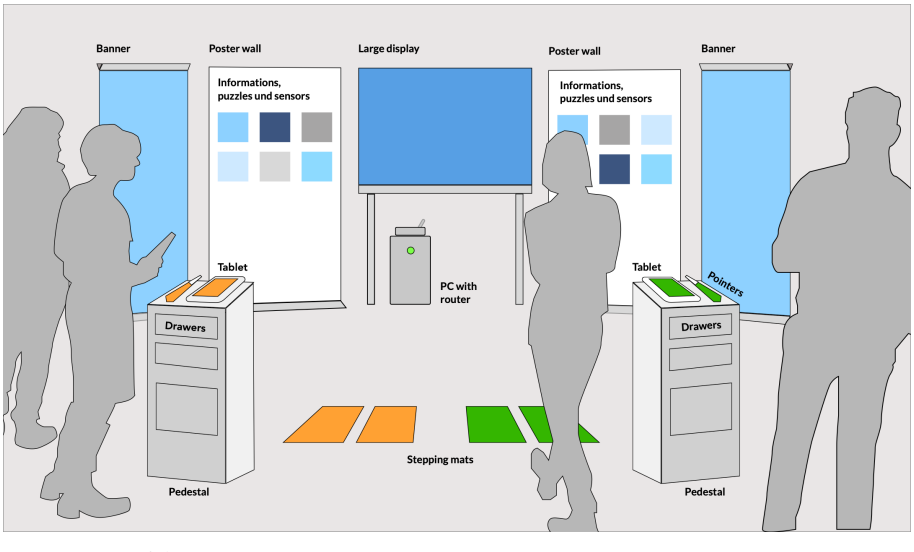

Fig. 3. *Set-up of the prototype.*

RFID sensors were attached to the back of images on posters or banners and facilitated economical and flexible interactions with printed content (Figure 4). The pointers contained the corresponding RFID near-field sensors and a direct Wi-Fi connection to the central computer. This way the pointers could be used to “select” items, images or text passages in the physical space and by doing integrate them into the game, for example to report information as found to the central PC and to trigger the next sequence.

The interplay between the large display, the tablets, finding content using the pointers on the posters in the room and the feedback from the overall system creates a feeling of “magical” technology. The individual digital and physical parts come together to create an interactive and responsive overall learning environment.

Fig. 4. *Two of our prototypically developed pointers.*

4.2 Game design and mechanics

The entire game was accompanied by an overarching story that took place in a fictional "Holodeck training lab" from the company on a distant palm-fringed island. The setting was deliberately chosen: the island transports you to a far-flung and airy world far away from the daily work routine, the "Holodeck" offers maximum flexibility in implementing different training contents. The atmosphere is kept non-threatening and friendly in accordance with the brief. The story is narrated and hosted by "Schnurps", the 3D cartoon character developed for this purpose (Figure 5). The somewhat clumsy figure, who asks the two teams for help, serves as an agent of sympathy and appeals to the empathy of the participants.

The overall solution consisted of a combination of three digital-physical game sections:

1) The story was introduced in a kick-off sequence, both teams were assembled at random via an initial interaction with the system and invited by "Schnurps" to participate. "Schnurps" then explained the shared aim of the game: to charge an energy cell by performing various activities in the training laboratory.

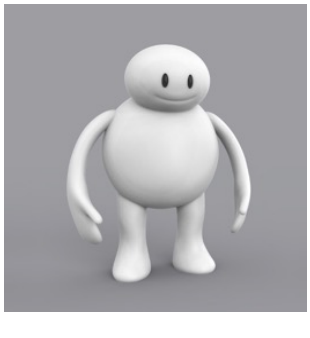

Fig. 5. *"Schnurps"— the host and identification figure.*

Then there was a brief introduction to each game accompanied by texts and graphics. The human game moderator accompanied these instructions by pointing out the associated game elements and, for example in the case of the pointers, demonstrating their use.

2) Subsequently, in the room-based puzzle “Enter the Code”, clues had to be found in the physical game room and assigned to their content using the pointers. Moreover, a small, augmented reality component was integrated, which allowed parts of the solution code to be discovered in some photos on the wall posters. This game, like all components, had a time limit, but did not reward solving the puzzle very quickly.

3) The grand finale took the form of a lively obstacle race that the teams could only master together and with distributed roles. The teams had to guide the game character “Schnurps” in real time over an obstacle course and to do so, they had to pick up virtual objects in physical space in time using the wands, which could then be employed in the game using the tablets. At the same time, 1-2 people per team had to move “Schnurps” around the course and avoid obstacles. The game was designed to combine previously learned knowledge, skill and team organisation. The game had a points counter and rewarded particularly skillful action. This led to a somewhat enhanced sporting spirit among the teams at the end of the game (Figure 6).

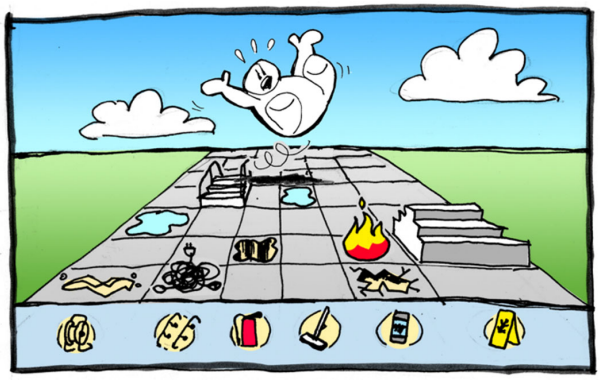

Fig. 6. *The “Obstacle Course” in which all the participants help “Schnurps” together.*

5 Application for staff training: Findings of the evaluation

In October 2018, eight test runs with the client’s employees were performed and evaluated in the university GamesLab and on the client’s premises. Two teams of 4-7 participants each were invited to play. One round lasted 45 minutes and was aimed at both fitters and office staff. The content was a health & safety training.

Following the game, the participants were interviewed in two steps employing a mix of methods: eight statements were surveyed in an one-page paper questionnaire. For each variable, five ordinally scaled answers were offered (Likert scales from “yes, absolutely” to “not at all” or “very good” to “very poor”).

Afterwards, the participants were asked in a feedback round to state in writing and verbally what they “liked” and what “could be improved”. Using inductive methods of qualitative content analysis [41], categories were identified to which the participants’ statements could be assigned. Building on the findings of Sailer and Homner’s study

[12], five controversial areas emerged, including Game Fiction, Social Interaction or Team Experience, Instructions, Game Design and Technology or the Hybrid Environment. A total of 40 participants took part in the evaluation.

5.1 Overall impression

The overall impression was clearly positive. Almost three quarters found the Live Learning Game application "Good" (62%) or even "Very good" (10%). Only two participants rated the overall impression as "Poor" and no one as "Very poor". Almost a quarter (23%) ticked "Average" (Figure 7).

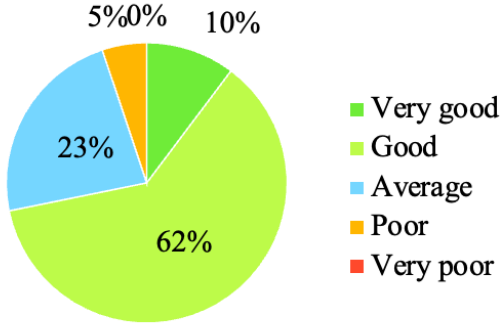

Fig. 7. Overall Impression

5.2 A collaborative hybrid game environment is fun

The best evaluations given by the participants can be found under "Team Experience" (Figure 8) and "I had fun" (Figure 9). Almost all participants agreed that the safety training session with the Live Learning Game was fun (92%). The teamwork was also very positively taken up and functioned smoothly. The participants agreed that it was motivating to have to work in a team and divide tasks among themselves. The sporting spirit was awakened. The participants were very pleased with the room concept in the Live Learning Game, which encourages self-initiative and the requisite communication within the team in parallel. Almost all participants rated the team experience positively (90%). Although the application was well received overall, room for improvement exists, especially with regard to the learning success.

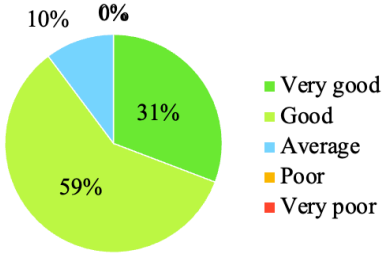

Fig. 8. The team experience

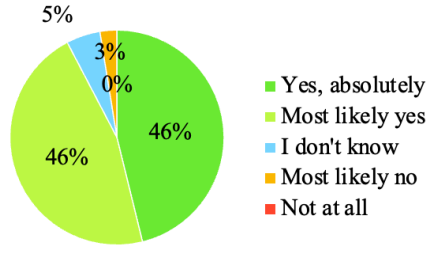

Fig. 9. I had fun

5.3 Playful learning in a hybrid environment

Overall, the ludic stimulus was perceived as very innovative and up-to-date. We received feedback that the games motivate participants to learn more and result in enhanced attention, because "you want to know what is happening". However, the lowest level of agreement was found in the area of learning-related aspects. While agreement prevailed here as well, this area shows the greatest need for improvement.

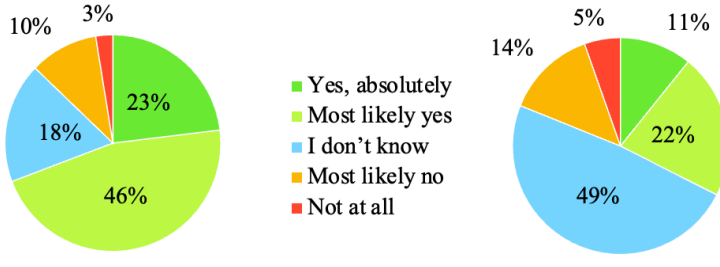

Fig. 10&11. 10) I can remember the content; 11) The method has helped me to remember the content

The statement made by the participants that they could "remember the contents" scored most highly (69%, Figure 10). Compared to the other learning-related questions, most participants said "yes, absolutely" (just under a quarter, 23%).

The statement "The method has helped me to understand the content" (Figure 11) accounts for the largest proportion of undecided respondents. Almost half of the respondents answered, "I don't know" (49%). The remaining participants were divided between agreeing (33 %) and disagreeing (19 %).

"The game has heightened my awareness for safe/unsafe situations" (Figure 12) and "The game has enhanced my motivation to adopt safety-conscious behaviour" (Figure 13). Although the accumulated agreement (57% and 61% respectively) clearly outweighs the accumulated disagreement (21% and 16% respectively), the proportion of

strong agreement (8% and 5% respectively) is relatively low. The proportion of undecided respondents is just under a quarter in both cases.

In summary, the evaluation data shows that in the prototype of the Live Learning Game, the level of motivation is primarily increased by the fun of the game and the team experience. Thus far, however, this has only had a moderate effect on the learning success.

Fig. 12&13. 12) The game has heightened my awareness for safe/unsafe situations; 13) The game has enhanced my motivation to adopt safety-conscious behaviour

5.4 Most controversial areas: Game design and instructions

In the feedback rounds, five areas could be inductively identified from the participants' statements on content.

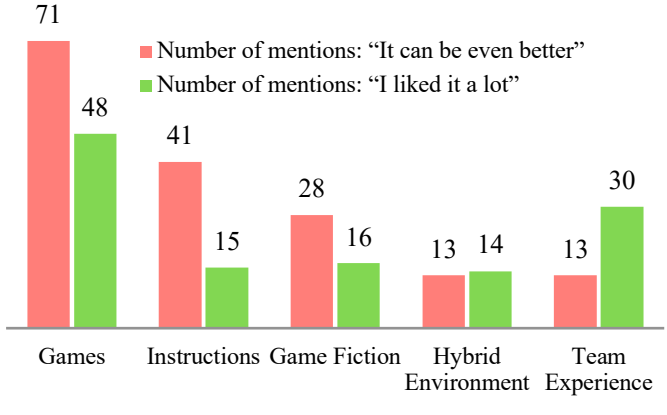

Fig. 14. Frequency distribution of criticism / praise in the five most important content areas.

Comparing how frequently they were mentioned, the most critical areas identified were the design of the game elements and their introductions and instructions. We received the most suggestions for improvement about the games themselves (Games). At the same time, the ludic elements and the method of playful learning enjoyed the most popularity. The relationship between the game mechanics and the teaching content was

discussed controversially. The aspect of teamwork and communication between the players (Team Experience) [18] stimulated by the system received a great deal of positive feedback. There was a strong need for improvement in the way the game was introduced and the instructions (Instructions) [12]. The hybrid structure and inclusion of physical and digital elements (Hybrid Environment) as well as an exciting game story (Game Fiction) [12] are a plus and can enrich the learning experience significantly and stimulate motivation. Ultimately, however, they are not as decisive for successful learning as a positive team experience, purposeful game moderation and, above all, a well-conceived game design with strong links to the teaching content (Figure 14).

6 Results, discussion and future directions: Human interaction with the hybrid game environment

The qualitative evaluation of the feedback and observations led us to the following results.

6.1 Result 1: Hybrid playful environments motivate participants to learn, but require a changed training mindset

The ludic stimulus and game elements were basically seen as very positive and offer a motivating introduction to a subject area. We received feedback that the method was very well suited to dealing with safety-related issues. Three participants said that they continued discussions immediately after the game. The Live Learning Game motivates participants to learn more and improves their concentration.

Both in the editorial work and game design it became evident that a changed teaching and training attitude also lies behind this approach. The playful experience and partly open-ended exploration also reflect issues otherwise discussed in teaching and industry: a generally ludic, pleasant interaction with one another, interdisciplinarity, interculturality, project and solution-oriented collaboration and ultimately at least a mitigation or even reversal of hierarchical relationships as well. If we want employees to act on their own initiative, we should trust them with more than a two-hour lecture accompanied by the 200 slides typical to a conventional safety briefing.

What did surprise us, was that some participants were almost irritated that they had been given so much freedom and that several requests were also made for more instructions. In the end, however, it was coping independently with precisely this level of freedom that led to a positive team experience and triggered the condition of autonomous motivation. This altered attitude to training led to wonderful “flow experiences”, i.e. moments of complete absorption in an activity, accompanied by unselfconscious joy [16] [36].

A question commonly asked by clients is: “How do you ensure that the participants have understood and internalised the training contents?” This is also a weak spot of more traditional lecture formats. Generally we would propose from our findings to specifically and individually process the sessions’ contents afterwards and to offer them as “take-away contents”. Since the system can log which sections were covered and with

which success, database-based publishing can be used to post-process the contents individually into a collection of tailored content for the teams—or even for individual participants.

One fairly simple form would render the contents into individual PDF files or web pages. More sophisticated and interactive variations could include parts of the Live Learning Game as online single-player versions, acting as a later assessment to reflect on what has been learned during the application. Formats could include quizzes or a virtual simulations of crucial parts of the Live Learning Game environment.

This single-player version, which the participants can continue to play at home, is also suitable to encourage further autonomous learning. A later stage of the Live Learning Game could emphasise tangential learning this way.

To address the problem that no additional feedback or assistance can be given to the learners [29], our approach could be combined with guided teaching units. Tangential learning does not replace guided teaching units nor joint reflection, but can enhance them and contribute to the long-term ingraining of the content, especially in the sense of self-motivation.

6.2 Result 2: The event character of hybrid game environments enhances powers of recall

The combination of different opportunities for physical and digital interaction is comparatively elaborate, but was also very well received and noticeably enriched the learning experience. In particular, the interactive combination of information provided on game tiles, posters and screens with the pointer in the game “Enter the Code” as well as the joint control of the digital “Obstacle Course” by means of physical stepping mats made the engagement with the content varied and, especially in teamwork, lots of fun. Only one person stated that he had been so absorbed by the prompts to interact that they no longer took in the content.

The use of many diverse technical elements alone is in itself appealing to some participants. However, they should also function smoothly, which was not always the case with the prototype at that time. The most frequently criticised element was the pointer, which was still quite prone to errors, and which did not always reliably recognise the objects.

The results of the evaluation show that one of the greatest strengths of hybrid teaching applications lies in their ability to create an immersive experience for the participants that is clearly different from the experience provided by a conventional frontal presentation or the regular work or training environment. Even though just under half of the participants were not sure whether the playful method helped them to understand the content (49% stated “I don’t know”), one of the great strengths of physical-digital learning environments appears to lie in activating memory recall (69% agreement). In this context, recalling learning content takes place in the context of a non-everyday experience, which is positively differentiated from everyday work, especially through the shared fun of gameplay. Ludic applications such as the Live Learning Game therefore indicated an event with positively connoted character, which is more comparable to the experience of a shared company outing than a regular training session.

6.3 Result 3: Hybrid game environments need a high level of design clarity

The prototyped game sequences were very well received. A relaxed, fun atmosphere and lively communication prevailed among the participants in the classic escape room combination game "Enter the Code". The feedback we received indicated that solving the puzzles was fun. However, objects and colours should be more clearly distinguishable from one another. In the prototype, a light blue and a dark blue were used, which led to confusion among the participants for a brief moment. Dynamic audio-visual feedback is also very important and could have been significantly stronger. The "Obstacle Course" with distributed roles was rated as fun and entertaining and forced activity and interaction between the participants. However, some participants needed more time to get used to the fast-paced game and to internalise the combination of physical and digital game components.

In principle, games should be designed so that game mechanisms can be recognised intuitively. This is especially true of games of skill, which require more time to familiarise oneself with how they work. Particular attention should be paid to clarity, especially in time-limited learning-related game applications. Short and easy-to-understand game rules, control instruments, colour codes, objects and task divisions inspire a positive team experience. In general, the use of clear, simple and friendly language is recommended, as well as the use of modern communication and information design wherever possible, for example by means of diagrams, symbols, animations, simulations, videos and soundscapes. Exciting and entertaining experiences are more elaborate than mere text panels, but their targeted use is worthwhile. Design clarity enhances the gameplay flow and experience and contributes to the learning motivation. One area for further research in this context is how to combine action game mechanics and learning content in meaningful ways.

6.4 Result 4: Collaborative competitive interaction design

Another frequently voiced suggestion was that the games should contain more competitive elements. Being faster and better should also be rewarded. However, it was important to the client and to us that the games were played together with team spirit and that no one was excluded. The solution was to have a dynamic of "playing together against one another".

Both groups participated in the same narrative and saw shared content on the central screen. At the same time, however, codes and puzzles were unique to each team and had to be entered independently on the respective tablets. Especially attentive teams that worked well together were thereby able to solve sub-tasks more quickly and collect more points. The resulting dynamic of "together against each other" is to some extent comparable to team sports. Two teams compete against each other, there exists the shared moment of teamwork and at the same time the sporting competition. There is an important difference here, however: both teams had to work together to successfully master the overall game. The positive effect here: in the end, everyone emerged victorious, only with different team scores.

The combination of competitive and collaborative game mechanisms inspired social interaction and consequently enhanced the participants' performance [10] [11]. Our

study thus confirms the finding of the gamification analysis by Sailer and Homner, that combining competition with collaboration is effective for fostering behavioral and motivational learning outcomes [12]. In relation to the Self-Determination Theory a mentality of "being there for one another" addresses the needs for social inclusion and competence, thereby strengthening the autonomous motivation to engage with the learning content together [15] [16] [17].

Team play was very well received in our pilot study. Nevertheless, future studies could investigate additional single-player applications for mandatory safety trainings to offer non-team player employees suitable formats as well.

6.5 Result 5: No one is left behind—difficulty levels, time markers and help systems

The level of difficulty greatly influenced the participants' level of motivation. Particularly games that arouse curiosity through a combination of a multitude of physical and digital interaction possibilities should not appear trivial due a level of difficulty that is too low. In the feedback round, this led to quite a few participants asking for the games to be made more difficult and more complex. However, participants grasp and master tasks at different speeds. Some have experience in ludic contexts, others need more time to find their way into a situation where they are an active participant. For example, the game design in the action-packed "Obstacle Course" required a certain level of dexterity when it came to inputting data and soon overwhelmed participants with little previous experience in computer games. The game sections, content and level of difficulty therefore need to be flexibly adaptable.

In order to take this into account and adhere to the client's target of 45 minutes per round every time, we divided the entire process into sections and provided each one with buffer time. At the same time, a clock kept running in the system, revealing incremental help at predefined time markers. The help gradually progressed from rather vague hints to solving the entire section. Our research shows that it is important to allow both the automated adjustment by means of time markers and the option for the game leader to adjust the level of difficulty.

6.6 Result 6: Strong link between content, gameplay and room design

Playful learning applications represent effective teaching approaches in which ludic aspects do not replace the content, but are designed to enrich it and promote its uptake [12] [19]. The focus is on the learning content. The team experience and the fun had while playing are effective mechanisms for stimulating motivation to engage with the content. Almost any content can be turned into a game. However, content exists that is more conducive to this and results in correspondingly more attractive games. Basic concepts can usually be easily transformed into games. More detailed factual knowledge can be packaged into animations, simulations and quizzes. If these are well written, participants will not deprive themselves of gaining real factual knowledge just by guessing.

As a consequence, most of our work did not so much involve advanced technological development, but rather down-to-earth editorial and design work. The basis for a good game-based learning experience should be the editing of the content. As highlighted by the participants' feedback, the content should be also closely linked to the gameplay and the room concept. For example, in the room-based puzzle game, the wish was expressed to hide even more clues in poster texts and thereby reward more intensive engagement with the content. For this purpose, texts and graphics need to be designed so that they are particularly easy and quick to grasp and are appealing. Especially in team games, the room design should allow several participants to access information simultaneously and to use physical and digital components.

The modular room design allowed the game space to be flexibly adapted according to the content required and the number of players (Figure 15). Movable partition walls and portable technology, among other elements, proved useful for this purpose. By opening up the game space, one team could watch the other or continue searching for information without disturbing the other. Further research could explore in more detail which room designs are best suited which specific gameplay designs and training contents.

Fig. 15. *Flexible set-up variants: corner stand open on two sides* (left)*, free-standing stair-like set-up* (centre) *and open floor plan, for example, in an adventure museum* (right).

6.7 Result 7: A narrative framework and coherent world design help

Incorporating appropriately designed game worlds, game characters and framework plots can foster learners' skills and invest more engagement in completing the tasks [12] [23], as it anchors learning in a context [20] and provides a thread to the game or learning process. The "Schnurps" character, the framework story of the training centre and the island setting were generally well received. However, five people found the make-up of the game and especially the game character a little too childish for a working environment. Important factors for positive reception are how well the game story is written and how attractively and consistently the aesthetic design is implemented [12]. However, the effort and outlay for production also increase accordingly in relation.

Admittedly, we had reasons for making our narrative and design decisions as derived from the concept. Nevertheless, participants will also exist who likely find themselves unable to identify with this particular version of a story and its style of delivery. As a direct learning concept, we intend to work with more abstract graphics in future to open

up access to as many participants as possible. For example, in future we would prefer not to model and animate the "Schnurps" character and its surroundings in three dimensions, but use a more economical and flexible 2D setting.

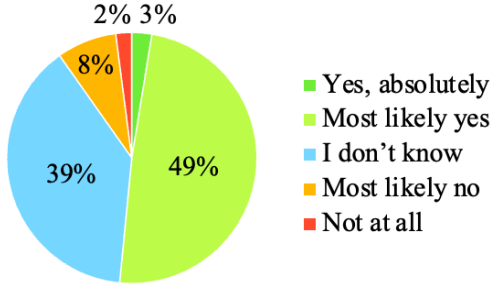

Fig. 16. The story make sense

Half of the respondents felt that the narrative and setting accompanying the game were basically coherent (52%, Figure 16). Only four participants found them to be inconclusive (10%). Over a third were undecided (39%). The most important suggestion for improvement was to stress the theme—safety at work—more and to tailor the narration, the setting and the room design more to it. We had also seen (and continue to see) the potential of individually designed game rooms during the design process. However, we had shelved them in our prototype in favour of a more universal—but correspondingly more generic—"training centre".

6.8 Result 8: Fiction requires relevance—but can also be abstract

A consistent aesthetic of the game world or a comprehensive narrative thread can serve as a cognitive framework for problem solving [34]. It is crucial that the narrative elements of the game have relevance throughout the learning unit, i.e. that there is a meaningful connection to the actions of the players and the learning content [10] [11] [26] [33]. However, this connection can also be designed in a more abstract way. For example, a safety training session does not have to take place in a production hall, as suggested by some test participants, but can also place the participants in an unusual fictional scenario—as long as the game world and narrative remain consistent and linked to the learning action. In our case, we deliberately created a setting that was clearly different from the participants' working environment. This was to help them discard the thought and behaviour patterns of their everyday work and open up the setting for an unconventional learning experience.

Many conventional escape rooms are staged productions with an almost museum-like character, decked out down to the last detail. Their disadvantage is that they are fixed to this specific narrative. In addition, they are comparatively maintenance-intensive and not very portable. Experience with our open and modular model shows that the concept of an escape game can also be implemented in a more abstract and virtualised way. As with drama rehearsals, participants also accept virtual or abstract boundaries within a physical-digital space, as well as its history and tasks. Real objects and

installations are part of the charm of these puzzle rooms. However, they can be extensively combined with digital surfaces, sensor technology, projection as well as lighting, sound and stage design to render entire sections of expensive and heavy structures in digital form. Miniatures and iconic models can also be used without sacrificing the contextual reference. In future research it would be useful to further investigate which level of abstractness is best suited which subject in which kind of training unit.

6.9 Result 9: Hybrid media environments encourage active engagement—preferably with human guidance

Systems in the real world generally require at least one supervisor who takes charge of tasks like event management, game management, moderation, assistance and even the maintenance, repair and resetting of the system. From the very beginning, our clients wanted the system to be run by as few personnel as possible. This is feasible in principle; these systems can be designed to be very largely self-contained. For example, software equivalents such as avatars, interactive help systems and virtualisations of real-world elements can be used.

Once you have arrived there conceptually, two follow-up questions arise: 1) can the solution also be implemented entirely as software and 2) does it make sense to implement the solution as online software (either for individual sessions or as a group experience). Both are very legitimate questions for training solutions which often handle many thousands of participants each year—and it is always worth considering these options.

In our experience, however, even a very well-made technical tutorial system and possibly supporting explanatory videos cannot replace the presence and flexibility of a qualified human game moderator. Particularly in a work context, a person should accompany the game for safety reasons alone, in order to be able to intervene if critical situations emerge. This can also counter the fear among technology-critical participants that they will be “dispatched” by computer-assisted systems. The presence of an accessible person creates trust and underlines the event-like character of a playful learning unit.

7 Conclusion

In summary, it can be concluded that the Live Learning Game has stimulating effects on the participants’ motivation to learn and to participate. This is particularly noteworthy as it was applied to a mandatory health & safety training which, under normal circumstances, is rather dry and not very engaging. Even though factors contributing to successful gamification or playful learning are still partially unresolved [12], the evaluation of several runs showed that content in particular can be well remembered due to the fun of playing and the positive team experience, especially the collaborative and competitive interaction design. Furthermore, a significantly higher level of engagement and interaction with the topic could be seen.

Regarding the research question, the combination of digital and physical game elements enriched the players' experiences and enhanced the collaborative learning experiences in a playful and motivating way. It leads to improved content retention, positive team experiences, raised awareness and provides many entry points for tangential learning and autonomous motivation. To accomplish this, it is critical to interconnect the design of the hybrid game space, the narrative framework and the gameplay with the teaching content in a direct and meaningful way.

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