Smart Learning Environments

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Reimagining how to understand learning game experiences: a qualitative and exploratory case study

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Abstract

While the use of games for learning in higher education is well established, existing research provides limited understanding of individual experiences that shape engagement and learning in collaborative learning games. Insights into players' individual experiences can, however, contribute to a more nuanced utilization of learning games and to better understand differences in individual learning outcomes. Therefore, this study seeks to explore how learning is experienced by players in a collaborative learning game. To achieve this, the study investigates the incentive and interaction dimensions of learning and the role of engagement and motivation for learning in an online collaborative board game using an exploratory qualitative case study approach. The study draws on diverse data comprising several sources, including in-depth interviews, observation of participants during a learning game, written free-form feedback, and a survey regarding the play experience. Results accentuate the role of individual and contextual differences, especially pertaining to prior knowledge and applying knowledge in realistic settings, perception of novelty related to game learning, and support from instructors and group members. Findings are further contextualized by positioning them into theoretical foundations related to transactive memory systems and collaborative engagement. Suggestions are made for collaborative learning game practitioners to strive for intragroup acquaintance and establishing purpose and use before play, and for instructors to be trained to dynamically adapt the type and amount of support provided based on player needs.

Keywords: Collaborative learning, Learning games, Higher education, Qualitative research, Learning, Engagement

Introduction

Using games for learning in higher education is a well-established practice (Boocock, 1970; Schuurman, 2017), which has increased drastically in prevalence following the growing ubiquity of digital media in the last two decades (Girard et al., 2013; Moizer et al., 2019). Following increased popularity, an increasing body of research illuminates learning conditions in games, emphasizing the role of engagement and motivation (Westera, 2019; Zhonggen, 2019). In a recent review of computer-based technology in higher education Schindler et al. (2017) found that digital games seem to foster cognitive

engagement through greater content understanding, higher-order thinking skills, and critical thinking. This seems to be supported by a positive effect on emotional engagement, specifically on learning attitudes, as games are commonly reported to be engrossing, interesting, and enjoyable (Anastasiadis et al., 2018; Schindler et al., 2017). In this study the term *learning game* refers to games that afford learning, albeit several other terms (e.g., *serious game*, *game-based learning*, and *educational game*) are often used to refer to similar kinds of games elsewhere.

However, the majority of current research tends to quantify engagement or motivation and learning (Klabbers, 2018; Wouters & van Oostendorp, 2017) to measure realization of intended learning outcomes (Biggs & Tang, 2009), promoting a one-sided focus on the cognitive dimension of learning (Bond et al., 2020; Castañeda & Selwyn, 2018; Järvelä et al., 2021; Wong & Csikszentmihalyi, 1991). This tendency has created significant knowledge gaps pertaining to experiential and social aspects of learning in games (Klabbers, 2018), and their motivational and affective foundations (Bond et al., 2020; Boyle et al., 2016; Wong & Csikszentmihalyi, 1991). Especially behavioral engagement and the emotional engagement indicator sense of belonging are understudied areas in the context of games in higher education (Schindler et al., 2017), and limited research effort has been afforded the topic altogether (Bond et al., 2020). Filling these knowledge gaps regarding learning, engagement, and their relationship is necessary to improve the understanding of how and why digital learning games may reform current instructional practices by fostering engagement and learning.

The current study aims to ameliorate these knowledge gaps and improve understanding of learning games through exploring individually experienced drivers and barriers of engagement and learning. To achieve this, a digital board game played online in a university learning environment is investigated, exploring engagement and learning experiences during play (Fredricks et al., 2004; Järvelä et al., 2016; Nkomo, 2021). The game being used employs collaborative groups to account for social aspects of learning and playing experiences (Klabbers, 2018; Sawyer, 2017) and afford insight into the role of interaction and sense of belonging in shaping engagement (Schindler et al., 2017). In pursuit of these aims, the guiding research question applied is "*How is engagement and learning experienced in a collaborative learning game?*". In answering this question an exploratory qualitative case study approach is applied, collecting diverse, detailed data (Flyvbjerg, 2011) through observations, interviews, written feedback, and a survey regarding the experience of playing and learning.

The social and experiential focus of the study sets it apart from the majority of research on learning games (Wouters & van Oostendorp, 2017) and engagement (Fredricks et al., 2016; Järvelä et al., 2021), and expands understanding of the relationship between engagement and learning in smart learning environments in higher education (Castañeda & Selwyn, 2018; Schindler et al., 2017). Such a shift in focus makes possible improved understanding of individual and contextual differences in drivers and barriers of engagement and learning in games (Boyle et al., 2016) in higher education (Bond et al., 2020). This shifted focus complements existing literature with insight into how individual experiences may provide a more nuanced understanding of learning, improve player experience, and contribute to achieving desired learning outcomes by investigating novel dimensions of learning. Additionally, the social and experiential focus

improves understanding of how to use games for educational purposes by identifying interrelationships between experiences of engagement and learning.

Literature review

Learning

Considering the mentioned lack of social, motivational, and affective consideration in research, a learning theory that accounts for all aspects of learning is critical. This study adheres to Illeris' (2018) understanding of learning as constituted by three ubiquitous dimensions. The *content dimension* deals with what is learned (knowledge, skills, etc.), how to construct meaning, and practical challenges, developing a personal functionality. Next, the *incentive dimension* concerns mental energy needed for learning (motivation/engagement, emotions, volition)—mobilizing and securing mental balance and developing personal sensitivity. Lastly, the *interaction dimension* regards environmental interaction situations (e.g., classrooms, workplaces) providing impulses that initiate learning, and the societal structure establishing premises of interaction. This happens through action, communication, cooperation, etc., and promotes integration in communities, developing sociality—the ability to engage and function in social interaction (Illeris, 2018).

Engagement

As the incentive dimension in Illeris' (2018) learning theory makes clear, engagement is foundational to learning (Järvelä et al., 2021), albeit the causal relationship between engagement, learning, and context remains unclear (Axelson & Flick, 2010). Engagement is commonly understood as consisting of behavioral, affective, and cognitive dimensions (Fredricks et al., 2004; Nkomo, 2021). *Behavioral engagement* concerns such topics as participation, effort, attention, and involvement which are necessary for learning outcomes. *Emotional engagement* deals with the positive and negative reactions to others (peers, lecturers, etc.), sense of belonging and identification—influencing "*willingness to do the work*" (Fredricks et al., 2004, p. 60). Lastly, *cognitive engagement* entails using self-regulated learning, being thoughtful, and exerting the effort needed for comprehension and skill mastery (Fredricks et al., 2004, 2016). Cognitive engagement is closely related to motivation, and motivation can be understood as subsumed by engagement (Reschly & Christenson, 2012).

Interrelation of engagement and learning in games

Empirical research provides further insight into the interrelation of engagement and learning during play. In connecting the gaming experience, i.e., relationship between game and player (Moizer et al., 2019), with engagement and learning, researchers have frequently used Csikszentmihalyi's (2014a) flow theory (Bellotti et al., 2013; Iten & Petko, 2016; Moizer et al., 2019). According to flow theory, balancing challenges with individual skills, experienced as neither too easy nor too difficult, can cause flow—a state of being fully immersed (Csikszentmihalyi, 2014a). Individuals experiencing flow, or flow antecedents like clear goals and immediate feedback, may experience a dedication and involvement beneficial to the experience of play (Kiili, 2005). Hence, flow is a strongly motivating experience (Csikszentmihalyi, 2014b) realized by the potential

motivational power of games (Westera, 2019), stimulating engagement. Because of this potential, and the positive effect of engagement for learning in general (Fredricks et al., 2016; Järvelä et al., 2021), understanding the interconnectedness of engagement and learning in games has become a lasting pursuit for researchers (Wouters & van Oostendorp, 2017). Previous research has shown that games used in an educational context aim to provide students with such an engaging, enjoyable learning experience (Nadolny et al., 2020; Plass et al., 2015; Vlachopoulos & Makri, 2017), but the occurrence of this is not a matter of course (Chen et al., 2015; Iten & Petko, 2016; Westera, 2015). However, learning games that offer collaboration (Anastasiadis et al., 2018; Wouters et al., 2013), autonomy through decision-making (Lamb et al., 2018; Westera, 2019), or immersion (Preuß, 2021) have been found to foster motivation and stimulate engagement (Fredricks et al., 2004; Rigby & Ryan, 2011). Further, students have been shown to achieve better content understanding and higher-order thinking skills (Schindler et al., 2017), as well as improved ability to see practical implications of theory when playing games, compared to lectures and readings (Lu et al., 2014)—although these effects have proven difficult to measure across settings and games (Bond et al., 2020).

Even though engagement factors in the cognitive dimension of learning (Wouters & van Oostendorp, 2017) and in learning game design (Charsky, 2010; Lameras et al., 2017; van der Meij et al., 2020) have been extensively researched, there is a lot left to learn about the interrelation between engagement and learning in games. These knowledge gaps become apparent in meta-analytic research, which has struggled to establish unambiguous links between learning and play in practice (Boyle et al., 2016; Mayer, 2019; Wouters & van Oostendorp, 2017; Zhonggen, 2019), especially pertaining to the role of interaction and play experiences. Regarding interaction, Schindler et al. (2017) found no studies looking at interaction as a behavioral engagement indicator, and only a single study looking at sense of belonging as an emotional engagement indicator, in their review of computer-based technology in higher education. In the broader context of collaboration as an indicator of learning, Wouters and van Oostendorp (2017) identified 18 pairwise comparisons in their meta-analysis, proving a small but significant effect size. However, only two of these studies (Day et al., 2007; van der Meij et al., 2011) account for the application of collaboration and are carried out in the higher education context. When the same analysis looked at collaboration and motivation, however, only two comparisons were found. Concerning play experiences, context of play in educational application and the role of individual differences or preferences are understudied areas believed to significantly impact engagement and learning (Backlund & Hendrix, 2013; Fredricks et al., 2016; Perttula et al., 2017; Vandercruysse & Elen, 2017).

Methods

Game context

The main learning goal of the studied game was practical application of intellectual property (IP) and IP rights (IPR) concepts (e.g., copyright, trademark, patents) in a business setting and the implications of this for competitiveness and business strategy. To achieve this, the game revolves around the story of a fictitious startup company with a product idea they intended to realize. The game, which was played online, contained a board, a card deck, and sticky notes, the gameboard was divided into 10 squares, one

for each topic to be covered in the game (e.g., assets, competition, challenges). Cards contained information related to the topics and happenings that progressed the story of the game. Sticky notes were stuck on the game board by players, with the aim of organizing and keeping track of information, decisions, emerging ideas, and narrative progression—in a manner accessible to everyone. To progress in the story and win the game, the players have to solve problems and make informed decisions. A graphical illustration of the game is included in Fig. 1.

The game had two main phases. First, players drew *information cards* and discussed the presented information, pertaining to topics such as market, competitors, or rules and regulations. This was used to make decisions about product features, roles, business goals, etc., working towards creating an IP/IPR strategy. Phase one was aimed at improving understanding of how IP/IPR is applied in practice and induce collaborative decision-making. In the second phase players drew *happening cards*, containing ill-structured problems such as "*a research institute contacts you, wanting to use your product in a project. Discuss and decide on a course of action*". Players then had to discuss and collaboratively find solutions that worked for them, as there was no one right way to solve problems. Few constraints were posed on available actions, yet all happenings were part of the ongoing story, so that decisions made impacted subsequent possibilities. The aim of the second phase was applying knowledge and decisions from the first part in 'practice', letting players experience how to use the theoretical concepts in a practical application. Additionally, a debrief was conducted wherein questions were answered and connections between theoretical concepts and practice were reinforced.

Since learning games are created for specific goals, a theoretical foundation should underpin design (Kafai & Burke, 2015; Lameras et al., 2017). This game relied on four foundational theories. First, Knowles' (2015) *andragogy* principles for adult instruction, positing that learning hinges on, e.g., a need to know (benefit or value of learning), relating to existing knowledge and experience, and self-direction (autonomy and

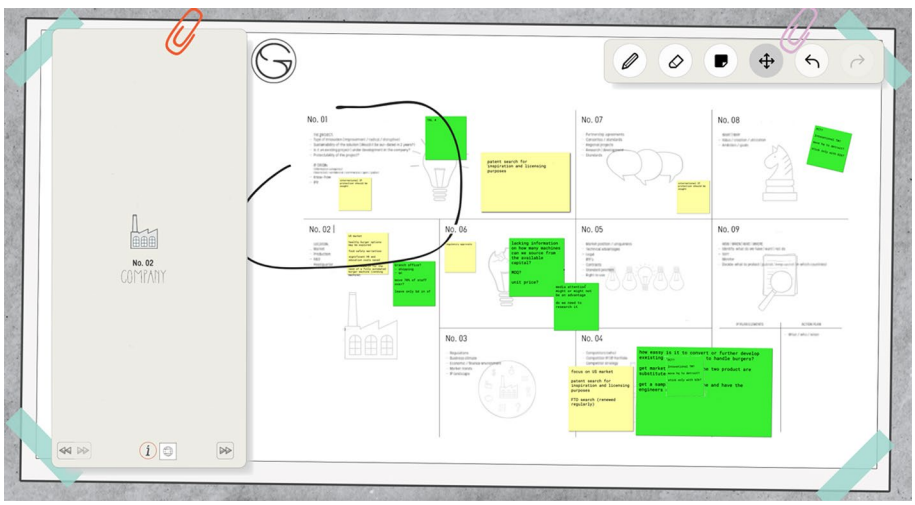

Fig. 1 Elements of the game—the gameboard, the card deck (on the left-hand side), and sticky notes in use. Players use the bottom left buttons to draw cards and the top right buttons to write, add sticky notes, and pan the board

responsibility for own decisions). In the game, the benefit of learning was demonstrated throughout on happening cards presenting scenarios in which knowledge about a specific topic was necessary to progress. To account for existing knowledge and experience, the game applies experiential techniques—"*techniques that tap into the experience of the learners*" (Knowles et al., 2005, p. 66)—such as group discussion, simulation, and problem solving throughout. Self-direction was ensured by letting players choose their own, creative approach to progress in the game, manifested especially through information cards which let players chose their roles, strategy, product, etc. freely. Second, Kolb's (2015) *experiential learning theory* propose that learning occurs in experiencing, reflecting on experience, conceptualizing from reflections, and acting to have new experiences. Progression in the game was organized similarly. Turns start with the drawing of an information/happening card containing happenings/information that impacts previous and upcoming decisions. Then, the happening/information prompted reflection and the formulation of a response or decision, which was conceptualized and implemented on the board in the form of sticky notes placed on the gameboard. Lastly, fulfilling the prompts posed in the information/happening cards enable experimentation with implications in new situations presented on subsequent cards, depending on previous decisions. Third, *situated learning* posits that learning is dependent on social context for supporting necessary difficult tasks (Lave & Wenger, 1991) and inseparable from the activity wherein it is developed (Brown et al., 1989). The game aimed to stay close to reality (the case in the game is derived from the real world and all happenings are scenarios that could or have happened in reality), and players were learning from each other and the facilitator through discussions and sharing of knowledge. Lastly, *self-determination theory* (Rigby & Ryan, 2011; Ryan & Deci, 2017), sees motivation and learning as linked, with motivation depending on the intrinsic needs of competence, autonomy, and relatedness (Brenner, 2022). Expanding abilities was a premise and a goal of the game made possible by open-endedness in the design, enabling players to contribute based on their knowledge and experience (competence). Furthermore, the game let players creatively explore putting theory into action to solve challenges posed by the information/happening cards (autonomy)—and doing so together with others, collaboratively (relatedness). By being designed based on these foundational theories, the game afforded collaborative problem solving, where players "[build] *mutual understandings of a shared problem, pooling together their expertise, skills, and efforts, and come up with* [solutions]" (Ouyang et al., 2021, p. 2).

Participant and play context

Players were 37 students attending a master's level course (unit/module) on technology management at a German university, with approximately as many women as men, largely in their mid to late 20 s. This course was conducted in English, as a majority of students had non-German nationality backgrounds. Participants' academic backgrounds varied significantly, but management, industrial engineering, and information systems management were among the most common. Topics covered in this course include strategy, business foresight, IP, corporate competitiveness, and technology analysis. At the beginning of the course students were assigned to groups of 4–5 for all subsequent group activities. The course was conducted entirely online and contained two segments—one

theoretical, one practical. Besides the game, the course consisted of traditional pedagogical approaches like lectures and group tasks. This particular participant group was chosen for study because their course curriculum matched the goals of the game, and because their diverse background could foster meaningful collaboration.

The play session being studied was used in the course to connect the theoretical and practical part within the topics of IP and strategy, providing the students with practical experience, albeit simulated, that could not be achieved using lectures. Prior to play, players did some preparations. First, they completed an e-learning program introducing IP/IPR. Second, students attended a lecture by an expert. Third, concepts were reiterated and connected to practice in a lecture using case examples. These preparations were applied to strengthen understanding of concepts used in the game. Play happened digitally using a web application for the game and video communication software for communication. Students were encouraged, but not required, to keep their camera on—which most did. Information about the game was given plenarily, before students were transferred to group video chats. Play lasted approximately five hours, with a one-hour break at the halfway point. Students were also free to take shorter breaks at their own discretion throughout. To support the play session, facilitators and subject matter experts were present. Facilitators were employees at the university familiar with the game, one facilitator was present in each group video chat. Facilitators were provided with prompts, hints, and potential solutions to aid participants' communication and progression, and were instructed to intervene in discussion if they sensed communication problems (e.g., players disengaging or being overbearing). Two IP practitioners acted as subject matter experts, which were called into group video chats by facilitators when necessary.

Study design and data collection

To address the identified research gaps and answer the research question, a qualitative case study was conducted. This approach was chosen because the role of interaction, context, and individual experience in learning games has been subject to limited qualitative research (Bond et al., 2020). Since learning games are constituted by manifold relationships between game, player, technology, and learning (Chen et al., 2015), making them complex, context-dependent, and multidisciplinary (Klabbers, 2018), qualitative research may afford novel insights. Handling of complex, immeasurable experiences (Lincoln et al., 2018), sensitivity to individual difference (Clarke, 2005, 2021), and elucidating how and why phenomena occur (Ravyse et al., 2017; Sawyer, 2004, 2017) are relevant strengths of qualitative research (Klabbers, 2018). Thus, questions pertaining to how and why people have different experiences with the same game (Alvesson & Kärreman, 2011; Maxwell, 2013; Moen & Middelthon, 2015), how participants experience play (Ravyse et al., 2017), and how collaboration shapes experience (Hassanien, 2007) should be investigated using a qualitative approach. Qualitative research may also foster understanding of game and player conditions, providing insight into individual differences and the role of contextual factors (Alvesson & Sköldberg, 2000; Järvelä et al., 2021). Learning game research thus benefits from qualitative approaches and may enable practitioners to better utilize games by enhancing understanding of variance in game experience. Additionally, a case study design enables holistic and rich representation of the situation by

accounting for context and individual difference through combining several sources of data (Flyvbjerg, 2011; Schwandt & Gates, 2018). This approach provides a nuanced vantage point from which to explore individually experienced learning and engagement in a situation that is consistent across participants.

Data collection began with observation of the full five-hour play session (with all 37 participants), which was carried out by watching and listening to play as it unfolded. Seeing as the game was played online, we achieved this by moving between group chats, observing one group at a time for a few minutes before moving to the next group Throughout the observation, notes were taken on behavior and interaction between players and the facilitator. Examples of notes taken include "facilitators are getting participants 'moving' when discussion is stagnant" and "several groups continued [discussing] into the allotted break time". Observation was used to gain a first-hand look at participants' interaction and collaboration, providing an indication of the involvement, enjoyment, and engagement experienced which is useful in answering the research question and for contextualizing interview data.

Interview recruiting started before play, by informing students about the research project. It was made clear that no reward was offered for participation. Recruiting interview participants continued in the days following play by the authors reaching out to students by mail. Simultaneously, one facilitator not otherwise engaged in the study was asked to participate due to facilitating a group wherein participants displayed what was perceived in observation as low engagement—which was interesting for answering the research question. All interviews, five in total, were carried out online using video communication 2–4 weeks after play. Interviews were conducted using a semistructured interview guide, containing topics to cover and follow-up probes used when needed. Questions were formulated in a manner that allowed participants to tell their stories and explain their experiences, rather than looking for specific information (Kvale, 1996). Examples of interview guide questions include "How was the discussion in your group?" and "Do you have any examples of discussions that were interesting to you?". In-depth interviews lasting up to 90 min were carried out with four participants from different groups and one facilitator. Interviews were transcribed verbatim with non-verbal expressions noted. In transcription and analysis, P1-P5 are used as monikers in lieu of participant names to ensure anonymity. Interviews were used because it enabled participants to explain and reflect on play experience and their perception of own engagement and learning in the game.

Beyond interviews and observations, four complimentary data sources were applied to account for multiple perspectives, broaden detail and variance (Flyvbjerg, 2011), and extend knowledge through data triangulation, i.e., combining various sorts of data (Flick, 2019).

- 19 students completed a five-question survey regarding their satisfaction (rating statements such as "*the game offered interesting insights into IP management*", "*we made use of the facilitator in our group*" on a five-point agreement scale), revealing a generally favorable impression. This provided an overarching, general understanding of player experiences. All students were given the opportunity to answer the survey, meaning the response rate was 51%.

- The second author facilitated one of the groups throughout, gaining insight particularly into their tacit knowing (Klabbers, 2018). This granular insight complemented the general observations of the groups, providing a more nuanced view of the play experience.
- 14 participants provided written feedback regarding their experience of the game, using an open-ended prompt ("*please indicate any further comments or suggestions you have related to the game*") to comment on their experience. Participant feedback contextualized survey responses and enhanced the total understanding of the situation. All 37 students were given the opportunity to provide written feedback, meaning the response rate was 38%.
- Following initial data analysis that raised focal issues on player experiences with the game, three facilitators not otherwise engaged in this study filled out a questionnaire about their perception of player experience – answering questions like "*did you perceive all participants as contributing equally to the group?*".

For data sources involving personal data, written consent from participants was collected after providing information about the research project, a declaration of voluntary participation, and the right to have identifying data rectified or deleted. To protect the privacy of participants and ensure confidentiality, all potentially identifying data was left out of transcription and research notes. See Fig. 2 for a graphical representation of data sources and their order of occurrence.

Data analysis

For the analysis of data, a constructivist grounded theory (Charmaz, 2014) inspired approach was used—a primarily qualitative methodology which sees data as a co-construction between the researcher(s) and participants, and the outcome of research as constructed interpretations. This approach to qualitative analysis favors inductive and

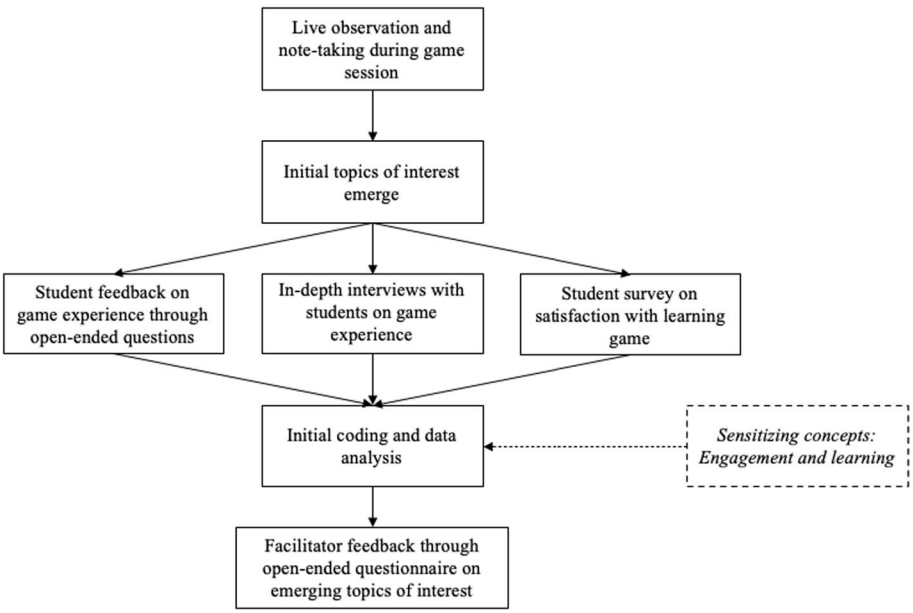

Fig. 2 Data sources and their order of occurrence

abductive (Timmermans & Tavory, 2012) inference for defining *generic processes*, processes cutting across empirical settings (Charmaz, 2014), enabling application of findings beyond the current setting. This fits well with the exploratory aims of the study, and the open-ended research question pursued. Furthermore, as constructivist grounded theory advocates analyzing data without applying a predetermined theoretical frame, openness to exploring interesting processes discovered during the empirical research was maintained. The core concepts of engagement and learning were, however, used as *sensitizing concepts*, i.e., broad concepts sparking thinking and providing tentative ideas to pursue (Charmaz, 2014). Also, grounded theory offers methodological flexibility accommodating the varied data sources and multiple, emerging perspectives. This inherent flexibility also allows for selecting analytical strategies based on the nature of the study being conducted. Seeing as this is a study concerning a single event, strategies such as comparing individuals at different times, theoretical sampling, and simultaneity in analysis and data collection were only partly feasible (Charmaz, 2021). Strategies used are described below alongside an explication of the research progression.

The first step in the analysis process was close reading of written material (interview transcripts, observation notes, and written feedback) to get familiarized with data. Second step was line-by-line coding, i.e., coding every line of written data using gerunds to emphasize actions and processes. As an example, the statement "*it stands and falls with the team you have*" was coded as "*perceiving collaboration as crucial*". Third came sorting line-by-line codes to construct overarching initial topics, establishing analytic directions. To ensure nothing was missed, and enhance credibility, these steps were carried out independently by two researchers and compared. Fourth step was focused coding, where initial codes and topics were synthesized and conceptualized, focusing on the most significant codes. For instance, the above participant statement became part of the focused code "learning as/in shared experience". This reduced the total number of codes from 559 to 43. The fifth step was sorting focused codes to write analytical memos. Memos, subsequently, were used as the basis for generating 16 intermediary categories through comparing data, concepts, and incidents, exploring potential theoretical connections. Sixth step entailed sorting and synthesizing of intermediary categories to construct the final four conceptual categories, of which the example statement became part of "collaborating via acquaintance". A list of focused codes, intermediary categories, and conceptual categories is included in "Appendix".

Results

To reiterate, the aim of this study is to ameliorate knowledge gaps concerning engagement in learning games through exploring individually experienced drivers and barriers of engagement and learning, answering the central research question "*how is engagement and learning experienced in a collaborative learning game?*". Results are presented as conceptual categories consisting of data excerpts and interpretive commentary—exploring how learning and engagement processes are experienced. Although engagement and learning are interrelated, results are divided into *engagement drivers* and *learning processes* depending on what is deemed most central to the experience. For each of these, two conceptual categories emerged during analysis—'*facing unfamiliarity*' and '*collaborating via acquaintance*' for the former, and '*bridging theory and practice*'

and '*progressing via facilitation*' in the latter. These categories are linked parts of the overall play experience, yet are considered separately to accentuate their relevance and importance.

Facing unfamiliarity

As collaborative play was a new approach to learning for most (and the current game was unfamiliar to all), participants grappled with an experienced *unfamiliarity* that seems to spur intense involvement with the game and drive behavioral engagement. The experience of handling unfamiliarity manifests as three sequentially related but distinct processes participants tackled.

First, at the onset of play, we observed that some participants had a hard time initiating play and interview statements made it clear that most participants had limited experience with learning games. This initial unfamiliarity is interpreted as creating interest and curiosity, by play being perceived as a break from the ordinary. However, curiosity was accompanied by uncertainty, of how to act and interact, perceived in actions and statements about challenges ("*avoiding leaving out valuable information*", "*[getting] lost in detail*", P4) that dissipated over time. Thus, curiosity and uncertainty experiences appear intertwined, with participants harnessing curiosity to get familiarized with the game and combat uncertainty. We did, however, also observe participants struggling to move past uncertainty, for which unfamiliarity became a barrier to engagement. This struggle is interpreted as related to a lack of communication and/or engagement, as this was observed in the same groups. Second, if initial difficulties are solved, experienced unfamiliarity becomes a positive force experienced as engaging and as promoting learning ("*I would have remembered [the content] for a shorter time had it been just a lecture…on longer perspective you can then remember…how it helped you*", P1; *I perceived the game to be quite interactive, and we had to discuss a lot, so this kept up my attention*", P3). This form of unfamiliarity experience is interpreted as creating intense involvement, driving behavioral engagement—especially trough active interaction. Novelty thus seems to be a central reason why participants get engaged in the game. In the third form of facing unfamiliarity, observed towards the end of play, unfamiliarity and the engagement that seems to follow it is perceived as mentally draining. This was experienced as exhaustion beyond what a normal day would cause. Participants reflecting on unfamiliarity state "*I was [exhausted] because of all this discussion and also little conflicts that sometimes arose in the team*", P4 and "*it was a really long day, and I can remember that I was very exhausted in the end*", P5. Exhaustion is understood as a reflection of having been intensely involved and active in the unfamiliar, collaborative play setting over time. Thus, unfamiliarity as draining does not equate to having had a negative experience but can also be an expected consequence of the mental exertion of being engaged over time.

The three forms of facing unfamiliarity are not oppositional, but rather constitute related experiences of becoming and being involved in a shared experience, driving behavioral and cognitive engagement. Although experienced intensity and involvement varies individually, our understanding is that it played a positive role in the overall play experience (if initial uncertainty was overcome). This category contributes to answering the research question by exploring a route through which participants became engaged, and how it is believed to aid content learning.

Collaborating via acquaintance

Collaboration is a crucial aspect of play, and a prerequisite for meaningful collaboration is a group that works well together. Participants in this study, in all but one group, knew each other prior to play, which mattered for collaboration. This established acquaintance seems crucial for becoming engaged and benefitting from collaboration in learning. Participants' experience of group interaction, for good and bad, illuminates how collaboration happens via acquaintance.

This comes to show through interview statements about group interaction, such as *"I [have] developed a sense of what are their specialties…and what they may not be good at"*, P3. P1 extends this by stating *"[discussing in the group] was actually pretty easy because we knew each other"* and P5, saying "*I really liked working together in a group, but I think…it's easier if you know your group, like it was in this case*". These statements are interpreted as intragroup interaction being driven by acquaintance, as participants benefit from knowing what to expect from others. This is further substantiated by how interaction was experienced, for instance "*we were able to interact freely and express our views and also participate…actively in the conversation, providing my inputs, discussing on the aspects provided by the others*" (P1) and "*it felt like a very open communication atmosphere*" (P4). We also observed that some groups' atmosphere seemed convivial, and conversations seemed to be flowing smoothly. We interpret this as establishing a relationship between being acquainted, knowing what to expect, and perceiving acquaintance as fostering close collaboration. This category thus entails an engaging experience wherein participants act and interact, interdependently working towards a common goal. However, acquaintance does not guarantee an engaging experience—it merely makes it possible, still relying on other engagement drivers. In fact, several participants did not commit to collaboration, either by disengaging ("*even with the small group size of four there was… one person that spoke less than the other three*", P3; "*one of the persons on that day was not so active*", P1) or by being overly active to the point of hindering others ("*[one was] more active, which was good, but also a bit controlling…and so this is another, I think, issue*", P2; *"[one person] was like affecting…the group dynamics, because [they were] very dominant…it was not like, balance in the group*", P5). In both cases, we perceive the benefit of collaboration is perceived as diminished by the actions—or inactions—of one person. These cases of non-collaboration show how acquaintance alone is insufficient for driving engagement, willingness to collaborate is still necessary. Additionally, one group wherein members were not acquainted further illuminates this—we observed that they required more time in the initial game phase to start working. Over time only two of the four group members—who knew each other—were actively working, while the others stopped contributing, even after encouragement from the facilitator.

Collaborating via acquaintance is thus understood as entailing shared action and interaction shaped by pre-existing relationships—connecting it to the interaction dimension of learning. Partaking in a collaborative learning process drives engagement if intragroup relationships are established, and every group member contributes to the process. This category contributes to answering the research question by expounding acquaintance as a driver of behavioral and emotional engagement, interpreted as crucial for learning through collaborative play.

Bridging theory and practice

In learning games that intend to simulate reality, the bridging of theoretical knowing to practical understanding is a foundational aim. In this study, that aim was made explicit, as it represents the intended role of the game in the course. This category explores how the learning process of applying theoretical knowledge in practice is experienced.

First, the experience of bridging necessitates a believable simulation—if the "bank" to which participants are expected to build their bridge is not clear, the practical application becomes muddled. This connection between verisimilar representation and practical application resonates with participant experiences. For instance, P3 states that "*I can imagine this [is] very realistic, very close to the reality so that's what I liked most about it*" and that they enjoyed *"applying this gained knowledge [from previous learning] which is … very helpful to grasp it and to get the gist of what should have been conveyed … it was tangible and also something I could imagine*". This experience is supported by other interview participants (e.g., "*yes, something like this [scenario] can happen*"; P1) and we observed it in how participants handled scenarios sincerely and involvedly. This understanding of the scenario as believable is further grounded in use expectation ("*we wouldn't have known that a company could reach you just for the sake of attention*", P1; "*it's really interesting and useful for the future to know where to look if you need some knowledge in [patenting]*", P5). We interpret this as a perceived connection between simulation and reality enabling connection between knowledge and applied understanding. This is further substantiated by survey responses being generally favorable (79% strongly-/ agree responses) regarding experienced insight into IP management. However, this also means that the experience of bridging necessitates adequate theoretical knowledge. Where theoretical knowing was perceived as lacking, we observed two basic strategies for dealing with the play situation emerging. Participants could either disengage, as one interview participant experienced a group member doing *("[one person] completely took [themself] out … [saying] 'I have to pass on that one because I have never looked into this topic before, and this is nothing for me right now' so [they] just [zoned] out"*, P4) or they could try to maintain engagement, as one participant did ("*I didn't know what I could add to the group, so I just started writing … the others were [talking a lot] … I decided I would just research and put in some stuff on the board*", P5). For these participants it becomes difficult to understand the simulation, whether the scenario is believable, and how to achieve practical understanding—due to the insufficient starting point. This was also observed in some participants that seemed to withdraw from the group process. However, it is likely that this active approach, staying involved, reduced negative aspects of lacking knowledge. Taking an active approach to dealing with lack of theoretical knowledge is likely contingent upon experiencing engagement in other ways (e.g., through collaboration).

In sum, the learning process of bridging theory and practice requires adequate knowledge, but also perceiving verisimilitude and future usefulness—accentuating the incentive dimension of learning. When lacking theoretical knowledge, increased behavioral engagement in pursuit of simultaneous attaining of said knowledge is needed, and can be supported by established engagement (e.g., sense of belonging in the group). This category contributes to answering the research question by exploring how the learning process of bridging is experienced and how engagement drives it.

Progressing via facilitation

Facilitators are present in games to aid participants during play, providing input when necessary for the group to become (and remain) engaged and learn. This category explores how participants experience facilitation as helpful for progressing through the game.

First, participants seem to experience facilitation as necessary, which resonates well with our observation of facilitator intervention to keep discussion productive and goal directed. For largely active groups, this required only minor nudges from the facilitator. P1 explains how this was experienced in such a group: *"[facilitator] did not provide the answers directly to us of course, but [they] tried to guide us in the right direction or if we have some insights related to the things that would come later on in the later pages … [they're] there"*. The same participant follows this up, explaining that "*[facilitator] also said sometimes that the discussion was too much, somehow [trying to] limit us in one direction, which was also good because then we might have saved some time*". What the participant calls saving time here, is interpreted as a way of keeping progression goal directed. Further, P5 states that "*if [facilitator] wouldn't have been there then; we didn't really know how to go through the task*". Despite these groups being active and engaged, they benefit from facilitation—participants would likely have been able to complete the game on their own, but facilitation makes it a smoother, less frustrating experience with less time waste and dead ends.

For groups that struggled with progressing, the need for facilitation was more pronounced—requiring the facilitator to take an active role. P2 explains that "*[players] weren't going deep enough, so there was this attitude of 'okay we just want to get all this through so we can get to the decision-making …sure we have addressed it, let's go to the next' and I felt like there was some issues here that we haven't discussed*". This group could maybe have completed the game alone, but without facilitation the learning experience is likely to have been lackluster due to neglecting discussion. We also observed facilitators stepping in and providing the necessary structure for progression. P2 follows up with their understanding of the challenge "*ultimately, it's not about solving or winning a game, ultimately it's about… understanding these concepts. [I said] '… think about the tension of this and that' and sometimes the answers were abrupt… so I tried to give some examples to kind of complexify the issues*". Participants in this group got more involved in the later stages but relying so heavily on facilitator support likely impeded learning. Furthermore, a secondary, affective facilitator role should be mentioned. P4 explains how they experienced this role with an example; *"[facilitator] was like 'hey… come on guys, you got it, you are on the right way, perfect,' then everyone felt kind of appreciated again and motivated again and we could further progress with the task*". Having facilitators in a motivational/supportive role likely improves the play experience—regardless of engagement level of participants.

Thus, progression, and therefore learning, seems to be contingent upon facilitation—regardless of how active and engaged participants are. However, the type and amount of support needed varies depending on how players act and interact on their own. As such, this category contributes to answering the research question by showing how malleability is an important property of facilitation that can aid learning by ensuring all dimensions of engagement are supported as needed.

Interrelation of categories

The categories highlight how experiences shape and are shaped by engagement and learning, but the four categories also relate to each other—constituting an overarching, albeit individual, experience (see Fig. 1 for a visualization of interrelations). These relations are not causal or ubiquitous, but rather tendencies revealed during analysis. First, when *facing unfamiliarity*, participants rely on intragroup interaction to reap the engagement benefits of novelty and reduce the mental drain that intense involvement can create. Such intragroup interaction is supported by the open communication and shared knowledge made possible by *collaborating* via *acquaintance*. Participants who know each other draw on pooled experience, collaboratively getting familiarized with play and managing intensity, further cementing the importance of intragroup relationships. Sharing responsibilities based on expertise can also alleviate unfamiliarity issues, as not everyone has to know and do everything. The collaborative nature of the game makes it stand out from the everyday routine of participants, cementing the relationship between the two engagement drivers. Second, part of the reason why *bridging theory and practice* is experienced as an impactful learning process (assuming sufficient existing knowledge) can also be understood by its novelty. Participants were not familiar with approaching learning in this practical manner, illustrating why play is experienced as intense and engaging. This is mediated by open communication and collaboration based on knowing the strengths of others, in addition to perceiving purpose and usefulness in the simulation. Lastly, learning *progression was guided by and dependent on facilitation* throughout the game. As such, this category takes an overarching role, alongside collaboration, as support helped participants face unfamiliarity, connect theory to practice, and use collaboration to their advantage. For participants that did not manage to sustain engagement on their own, progression would likely cease or be reduced, if not for the support offered by facilitators.

In sum, *facing unfamiliarity* and *bridging theory and practice* are interpreted as procedural processes, representing actions taken and challenges overcome, driving engagement and learning—or becoming barriers, for participants who are unable or unwilling to engage. Making these processes happen seems to depend on sufficient theoretical knowledge and perceiving the game as having purpose and being useful. Additionally, the categories of *collaborating* via *acquaintance* and *progressing* via *facilitation* support the procedural experiences, making action possible. Positive intragroup relationships and perceived facilitator support seems necessary for the support experiences' fruition. It also follows from this that participants who did not receive adequate support from facilitators, and who are unable to benefit from acquaintance, are less likely to become engaged and learn. See Fig. 3 for a graphical presentation of category interrelations.

Discussion

To answer the central research question, "*how is engagement and learning experienced in a collaborative learning game?*", the presented findings are discussed in relation to existing knowledge within relevant topics.

Within the topic of experienced engagement, our findings regarding facing unfamiliar situations extend current research on game engagement formation (Boyle et al., 2016;

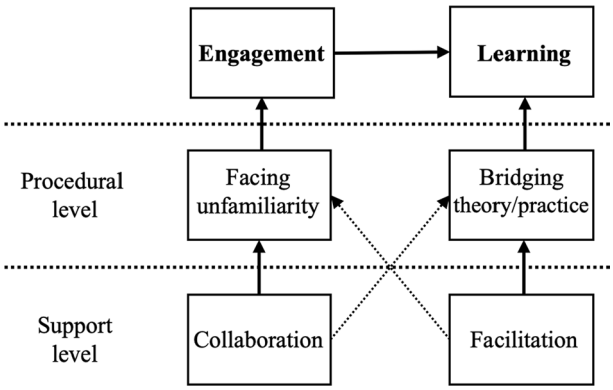

Fig. 3 Category interrelations and connection to engagement and learning

Jabbar & Felicia, 2015) by exploring the link between novelty and becoming engaged. Results suggest that unfamiliarity, if mastered, drives engagement through novelty and breaking of routines, being experienced as interesting and involving. We interpret this as supporting previous research on novelty (Riopel et al., 2019) or familiarization (van Roy & Zaman, 2018) effects in learning, and establishing a link to engagement as contingent upon interest (Fredricks et al., 2004) and experienced mastery (Rigby & Ryan, 2011). Thus, we argue that the novelty effect arising through unfamiliarity may guide learning game application and frequency of use, based in part on how participants are usually learning. Also, if novelty becomes too much to handle it may hinder flow (Csikszentmihalyi, 2014a) and mastery (Ryan & Deci, 2017), and so unfamiliarity must be congruent with participants' abilities (Muukkonen & Lakkala, 2009). As such, these findings contribute to filling identified knowledge gaps pertaining to the context of play and the role of individual differences in shaping play experience (Klabbers, 2018; Perttula et al., 2017; Vandercruysse & Elen, 2017) and forming emotional engagement (Schindler et al., 2017).

Furthermore, the results regarding the experience of engagement extend previous research on engagement and learning in collaborative games (Chen et al., 2015; Vlachopoulos & Makri, 2017) by accounting for existing intragroup relationships. Our analyses suggest that for collaboration to work well, i.e., drive engagement and learning, participants use acquaintance and knowledge about other's strengths to support each other and pool knowledge. This is in line with previous research on group collaboration as accentuating the relational aspects of learning and engagement (Van den Bossche et al., 2006) or flow (Sawyer, 2017) in non-game settings. Moreover, we believe the integral role of collaboration in the game contributed to the experience of acquaintance as beneficial. Previous studies commonly investigate collaboration in games that does not require it (e.g., Chen & Law, 2016; van der Meij et al., 2020) which could reduce the usefulness of collaboration and acquaintance due to diminished integration and importance in these games. This could also contribute to understanding why meta-analyses attempting to link learning and collaboration (e.g., Wouters & van Oostendorp, 2017; Wouters et al., 2013) report ambiguous results. These findings thus contribute to filling identified research gaps regarding social aspects of play (Klabbers, 2018) and interaction as shaping behavioral engagement (Schindler et al., 2017), as well as the conditions for collaboration (Van den Bossche et al., 2006; Wouters & van Oostendorp, 2017) and sense of

belonging within a learning community for shaping emotional engagement (Schindler et al., 2017).

Within the topic of experienced learning drivers, results on utilizing existing theoretical knowledge extends research on the role of prior knowledge in instruction (Dunlosky et al., 2013; Zambrano et al., 2019) by accounting for how theoretical knowledge fosters attaining practical knowledge. Our results suggest a specific application of prior knowledge—building practical competence from theoretical knowledge acquired previously. This also extends previous research on learning games that explore unspecified capability utilization (e.g., Iten & Petko, 2016; Yang & Quadir, 2018) and integration in long-term memory (e.g., Mayer, 2019; Wouters & van Oostendorp, 2017). As such, we argue that it is useful to move beyond seeing prior knowledge as something participants do or do not possess, to considering also how it is used and how it aids game learning. In this regard, our findings suggest that using existing knowledge is needed for perceiving usefulness and purpose—which fosters engagement (Wang et al., 2017) and learning (Schwägele et al., 2021). This finding thus contributes to ameliorate identified research gaps related to play experience by establishing how context and individual differences (Castañeda & Selwyn, 2018) may drive (content dimension) learning (Illeris, 2018; Vandercruysse & Elen, 2017) through the differentiated application of prior knowledge.

Furthermore, regarding learning support, our findings extend current research on facilitation of collaborative learning games (Kortmann & Peters, 2021; Taylor, 2014) by accounting for the diverse support participants require to engage and learn. We find that different players require substantially different support in play, meaning facilitation must be malleable in amount and complexity—as well as across the dimensions of learning. Especially the affective role (incentive dimension) was an important addition to content facilitation, resonating with previous research on group facilitation outside learning games (Heron, 2005; Schwarz, 2017). We find that facilitators engaging in affective support were able to keep participants' spirits up in the face of adversity and argue that more emphasis on the affective dynamic of the group would be beneficial. This requires a rethinking of how facilitators operate during play, which can extend current research like Kortmann and Peters' (2021) competency model for game facilitation by including, for instance, Heron's (2005) feeling dimension. This finding contributes to filling identified knowledge gaps by improving understanding of how facilitators may attend to the affective dimension of learning and individual differences (Illeris, 2018; Vandercruysse & Elen, 2017), in part making interaction (behavioral engagement) and sense of belonging (emotional engagement) more tenable for participants (Schindler et al., 2017).

Theoretical implications

Our findings enabled the application of two additional theories, outside the theoretical foundation of the study, to which the study can contribute. As such, we contribute to further theoretical advancement by exploring how these established theories can be expanded by the learning game context.

First, the analysis revealed resemblance between participant' experiences and key characteristics of *transactive memory system* (TMS). TMSs entail "*a cognitive division of labor based on shared awareness of who knows what*" (Peltokorpi, 2008, p. 378), created by becoming aware of others' knowledge, remembering differences, and retrieving

relevant knowledge when required (e.g., Hollingshead & Brandon, 2003; Peltokorpi, 2008). This improves learning and transfer, collective information memory, and increases group efficiency (Brandon & Hollingshead, 2004; Lewis et al., 2005). In learning game research, Super et al. (2020) found that established TMSs foster higher perceived group performance and positive game experiences, and that positive outcomes of TMSs make groups want to engage in future coursework using the game. Our study provides complementary results, as participants perceived collaboration as engaging, contributing to their learning experience. We extend this by improving understanding of the emergence of knowledge sharing behaviors in the learning game setting, advancing TMS theorization in three ways. First, we find that game performance is improved by a learning environment characterized by freely shared knowledge that TMSs foster by raising individuals' awareness about group abilities. This suggests an interrelation between learning performance and transactive memory. Second, while a TMS can be established autonomously (Lewis et al., 2005), we find that instructors who enable and facilitate groups getting to know each other before and during play improve the construction and use of TMSs. This adds to knowledge regarding the formation of TMSs. Third, game learning approaches can result in high mental workload, which may cause disengagement and exhaustion. We find that TMSs can reduce workload through utilizing and coordinating individual knowledge for tasks, contributing to maintain engagement. This finding suggests a link between TMS and engagement in the game setting.

Second, our findings accentuate the malleability of engagement and the role of the group in shaping it. This resonates with *collaborative engagement* (Järvelä et al., 2016), an engagement theory accounting for the influence of context and interaction in collaborative learning by seeing engagement in learning as a process divided into forethought, performance, and reflection (Cleary & Zimmerman, 2012). This expands the established understanding of interaction as *behavioral* engagement (Bond et al., 2020; Schindler et al., 2017), to include *cognitive* (task-focused or metacognitive discussion) and *socioemotional interaction* (discussion and expression of emotions or motivation) during collaboration (Järvelä et al., 2016). Furthermore, Järvelä et al (2016) find that ill-structured (as opposed to well-structured) tasks support use of both interaction types. The current study contributes to this by showing how such interaction play out during ill-structured tasks in learning games, advancing collaborative engagement theorizing in the learning game context in three ways. First, during forethought, our findings show that participants experienced initial uncertainty as challenging, which was solved by discussing information and progression (cognitive interaction), but only in groups that expressed positive emotion (socioemotional interaction). This indicates that forethought processes like task analysis and strategic planning (Cleary & Zimmerman, 2012) are mediated by socioemotional interaction. Second, during performance, we find that participants using metacognitive discussion for tracking and adjusting group performance (cognitive interaction) attribute this to intragroup motivation and positive emotion (socioemotional interaction). These two points contribute to current theorizing by showing how the two types of interaction are interdependent in the collaborative learning game context. Lastly, we argue that, while individuals collaboratively shape their shared interaction, collaborative engagement can be supported. Facilitators may mediate how collaborative engagement pans out by encouraging and facilitating the use of both

types of interaction. This contributes to advance theory by showcasing the strengths of a potential third task type, in addition to *student-led* and *teacher-led* (Järvelä et al., 2016), i.e., *facilitator-mediated*.

Practical Implications

This study may provide guidance for smart learning practitioners using collaborative learning games in higher education, as findings emphasize the necessity for instructors and facilitators to actively shape learning experiences. How to apply these insights will depend on what game is being used and the context in which it is played.

First, instructors should communicate and explain to players what the game entails, its goals, and how to achieve them before the game. This can be achieved by recognizing what prior knowledge is needed and how it can be applied, as well as considering how less knowledgeable players may contribute. This helps establish the game as purposeful, useful, and close to reality.

Second, enabling participants to get to know their group members before the game facilitates a positive play experience. This can be achieved by having players work on a separate task to reveal individual strengths and weaknesses, preferences, and experiences. This is useful because learning is experienced as more engaging and goal-directed when participants know each other.

Third, instructors should be sensitive to individual differences in communication and interaction. This can be achieved by ensuring equal opportunity for participation through encouraging open and active communication—for instance by inviting quieter players to speak their mind. This helps to create a balanced collaborative learning environment wherein everyone may engage freely.

Lastly, instructors must be aware of the needs of different groups. Highly engaged groups require limited support (e.g., providing guidance and streamlining discussion) whereas groups demonstrating lower engagement requires more extensive support (e.g., content-related advice, affective support, and novel input) to improve progression and stimulate communication. To achieve this, instructors should pay close attention to group level engagement and adjust their support behavior accordingly. This is valuable because it helps create a positive game experience by adapting to group level conditions.

Limitations and future research

Although the exploratory approach applied led to interesting findings, the study is subject to limitations. Overarchingly, it should be noted that, due to the qualitative nature and small sample of the study, the points under discussion are not necessarily generalizable to all collaborative learning games. However, by presenting detailed descriptions of context and results, ways in which findings may be extrapolated to similar contexts are demonstrated. This alternative to generalizability is commonly called transferability, and is a more suitable approach to relating findings to other contexts in qualitative research (Polit & Beck, 2010).

First, the digital medium enabled players to disengage from the game easily, e.g., through turning off the camera, which would not have been possible in a physical game setting. Moreover, people communicate not only verbally, but also through nonverbal cues like gestures, body postures, and facial expressions (Burgoon et al., 2010), which is

more difficult to accomplish in a digital setting (Almås et al., 2021). In fact, the role of affect, which includes such feelings, for learning and engagement was mentioned both for itself and as part of facilitator support. Replicating the study in a face-to-face setting could thus offer additional findings on disengagement, which is more difficult in a classroom compared to virtual play, and the role of affect in non-verbal communication.

Second, the studied game relies on human facilitators to support interaction and learning, which we found to be an important element in shaping the game experience. However, having one facilitator present in every group throughout a game can be expensive and time-consuming, putting significant constraints on the scale of application in practice. To alleviate such challenges, it may be viable to employ non-human facilitation, i.e., an artificial character that takes on some of the facilitator duties—either as a supplement to human facilitation or as a replacement, potentially supported by artificial intelligence (cf. Baalsrud Hauge et al., 2021). Future research should consider whether and how an artificial character may incorporate the findings of this study to determine which of the proposed facilitator duties can be achieved without human involvement.

Third, engagement and motivation in the game was mostly intrinsic, as results were not graded or otherwise evaluated—the central goal of the played game was to enhance learning, and it was communicated accordingly prior to the game. This was done to create an enjoyable experience wherein collaboration and learning was prioritized over winning. Still, grading results could have offered an extrinsic, second layer of motivation. As such, findings in this study cannot necessarily be generalized towards games that include evaluation. Adding explicit extrinsic motivation is thus a direction for future research to complement the findings of this study, and to explore how players might change their behavior and engagement due to altered motivation.

Fourth, we found the theoretical positions of TMS and collaborative engagement to be supported and expanded by the results, despite not considering these theories until after analysis due to the nature of the grounded theory approach. This, however, lends grounded support for future studies on learning games that these connections are deemed relevant by players for learning and engagement. Future studies are encouraged to explore connections between collaborative games and theoretical underpinnings of TMS and collaborative engagement in greater detail by designing play and/or studies accordingly. For instance, we believe that a field experiment manipulating the level of TMS and exploring potential differences in performance holds great potential. This could make possible a more detailed understanding of the effectiveness of TMSs in this setting, and whether groups having established different levels of TMS experience different drivers and barriers to engagement and learning.

Conclusion

The central question of this study, "*how is engagement and learning experienced in a collaborative learning game?*", addressed the role of individual player experiences for learning and engagement in a collaborative learning game in the context of higher education. Our findings emphasize that engagement was primarily driven by experiencing novelty and unfamiliarity through learning by playing a game, and by collaborating in groups that got acquainted prior to the game. Central factors that shaped learning were receiving facilitation for progression and the awareness of applying knowledge in a relevant

and realistic scenario. While distinct, these factors are interrelated and jointly shaped the overall gaming experience of the studied players, highlighting the need to employ a holistic approach when aiming to understand how engagement and learning occurs in collaborative learning games.

Findings from the current study underline the importance of player perceptions and experiences in the application of learning games. This represents a shift in focus compared to most current research—from what is learned to how learning happens—which we believe to be a fruitful angle for research that can strengthen understanding of collaborative learning games. Although the practical and theoretical implications postulated above are rudimentary at the current stage, they provide a foundation for such a shift in focus towards how learning happens. Transactive memory systems and collaborative engagement are posited as especially potent for understanding findings in the current game, but further investigation is needed to determine whether this holds true for other contexts. Finally, we appreciate that the current study is not exhaustive—there are likely other concepts and theories that can help explain how engagement and learning is experienced in games—accentuating the need for further exploratory research.

Appendix: Codes and categories

The below list presents focused codes (in boldface), intermediary categories, and focused codes (in italics) and their interrelation as constructed in the analysis.

Facing unfamiliarity

Participating actively

Being motivated to participate actively (fear of wasting time)

Getting bogged down in minutiae

Getting bogged down in minutiae
Information overload

Intensity by novelty

Exhaustion by engagement
Game design causing engagement
Novelty-intensity of playing
Remembering game experiences due to novelty/rarity

Breaking with day-to-day

Active participation setting apart from everyday routine
Novel possibilities of digital play
Overwhelmed due to engagement

Collaborating via acquaintance

Knowing each other

Having knowledge from before

Interaction sustaining engagement and attention
Intragroup acquaintance – openness and trust (competence)
The demanding but rewarding process of accounting for different perspectives whilst/for reaching agreement

Drawing on differences

Disagreement on how to best deal with vast information
Imperfect intragroup participation balancing
Quiet – disengaged distinction
Solving problems collaboratively
Using collaborative decision making to progress in game

Relying on collaboration

Building a scenario by imagining together
Favoring group work, generally
Lack of collaborative skill applicability (decision-making)
Learning as/in shared experience
Resolving problems as a team
Wanting intergroup interaction

Bridging theory and practice

Verisimilar praxis

Believable/verisimilar case
Relating learning to previous experience
Seeing connection theory-praxis

Taking it seriously

Believing new practical understanding to be useful in further studies/work-life
Seeing the one-day format as meaningful and intense, yet fragile

Attributing outcome to eLearning

Attributing learning to eLearning/lecture
Being primed for practical application by lecture and eLearning
Understanding and collaborative skills as contingent upon insight from theory/eLearning

Progressing via facilitation

Winning rather than learning

Efficiency/winning prioritized over learning (taking roles to progress quicker)
Unclear use of collaborative skills

Needing facilitation

Facilitation as a necessity for progression
Facilitation dissatisfaction (reasoning)

Helpful facilitation
Using collaborative skill time management

Learning "wrong"

Balancing role-taking with participation/ learning on everything
Struggling to see distinction hard constraints – tweakable directions

Discarded

Emotional investment

Confusing rules and layout

Extraneous strain from digital play
Game design causing confusion/dislike

Abbreviations

IP	Intellectual property
IPR	Intellectual property rights
TMS	Transactive memory system

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The manuscript was written by HA and FP. Data collection and analysis was carried out by FP and HA. FG substantially revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available due to internal confidentiality concerns but are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare that they have no competing interests.

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References

Almås, H., Hakvåg, M., Oliveira, M., & Torvatn, H. (2021). Participant centred framework to support the digital transformation of boardgames for skill development. In B. Fletcher, M. Ma, S. Göbel, J. Baalsrud-Hauge, & T. Marsh (Eds.), *Serious games* (Vol. 12945, pp. 85–97). Springer. https://doi.org/10.1007/978-3-030-88272-3_7

Alvesson, M., & Kärreman, D. (2011). *Qualitative research and theory development: Mystery as method*. SAGE.

Alvesson, M., & Sköldberg, K. (2000). *Reflexive methodology: New vistas for qualitative research*. SAGE.

Anastasiadis, T., Lampropoulos, G., & Siakas, K. (2018). Digital game-based learning and serious games in education. *International Journal of Advances in Scientific Research and Engineering, 4*(12), 139–144. https://doi.org/10.31695/IJASRE.2018.33016

Axelson, R. D., & Flick, A. (2010). Defining student engagement. *Change: the Magazine of Higher Learning, 43*(1), 38–43. https://doi.org/10.1080/00091383.2011.533096

Baalsrud Hauge, J., Söbke, H., Bröker, T., Lim, T., Luccini, A. M., Kornevs, M., & Meijer, S. (2021). Current competencies of game facilitators and their potential optimization in higher education: Multimethod study. *JMIR Serious Games, 9*(2), e25481. https://doi.org/10.2196/25481

Backlund, P., & Hendrix, M. (2013). Educational games—Are they worth the effort? A literature survey of the effectiveness of serious games. In *2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)* (pp. 1–8). https://doi.org/10.1109/VS-GAMES.2013.6624226

Bellotti, F., Kapralos, B., Lee, K., Moreno-Ger, P., & Berta, R. (2013). Assessment in and of serious games: An overview. *Advances in Human-Computer Interaction, 2013*, 1–11. https://doi.org/10.1155/2013/136864
Biggs, J. B., & Tang, C. S. (2009). *Teaching for quality learning at university: What the student does* (3rd ed.). McGraw-Hill.
Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education, 17*(1), 2. https://doi.org/10.1186/s41239-019-0176-8
Boocock, S. S. (1970). Using simulation games in college courses. *Simulation & Games, 1*(1), 67–79. https://doi.org/10.1177/104687817000100106
Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education, 94*, 178–192. https://doi.org/10.1016/j.compedu.2015.11.003
Brandon, D. P., & Hollingshead, A. B. (2004). Transactive memory systems in organizations: Matching tasks, expertise, and people. *Organization Science, 15*(6), 633–644. https://doi.org/10.1287/orsc.1040.0069
Brenner, C. A. (2022). Self-regulated learning, self-determination theory and teacher candidates' development of competency-based teaching practices. *Smart Learning Environments, 9*(1), 3. https://doi.org/10.1186/s40561-021-00184-5
Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.
Burgoon, J. K., Guerrero, L. K., & Floyd, K. (2010). *Nonverbal communication*. Allyn & Bacon.
Castañeda, L., & Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education, 15*(1), 22. https://doi.org/10.1186/s41239-018-0109-y
Charmaz, K. (2014). *Constructing grounded theory* (2nd ed.). Sage.
Charmaz, K. (2021). The genesis, grounds, and growth of constructivist grounded theory. In J. M. Morse, B. Bowers, K. Charmaz, A. Clarke, J. Corbin, C. J. Porr, & P. N. Stern (Eds.), *Developing grounded theory: The second generation revisited* (2nd ed.). Routledge.
Charsky, D. (2010). From edutainment to serious games: A change in the use of game characteristics. *Games and Culture, 5*(2), 177–198. https://doi.org/10.1177/1555412009354727
Chen, C.-H., & Law, V. (2016). Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation. *Computers in Human Behavior, 55*, 1201–1212. https://doi.org/10.1016/j.chb.2015.03.010
Chen, C.-H., Wang, K.-C., & Lin, Y.-H. (2015). The comparison of solitary and collaborative modes of game-based learning on students' science learning and motivation. *Educational Technology & Society, 18*(2), 237–248.
Clarke, A. (2005). *Situational analysis: Grounded theory after the postmodern turn*. Sage Publications.
Clarke, A. (2021). From grounded theory to situational analysis. In J. M. Morse, B. Bowers, K. Charmaz, A. Clarke, J. Corbin, C. J. Porr, & P. N. Stern (Eds.), *Developing grounded theory: The second generation revisited* (2nd ed.). Routledge.
Cleary, T., & Zimmerman, B. (2012). A cyclical self-regulatory account of student engagement: Theoretical foundations and applications. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 237–258). Springer US. https://doi.org/10.1007/978-1-4614-2018-7
Csikszentmihalyi, M. (2014a). *Applications of flow in human development and education*. Springer Netherlands.
Csikszentmihalyi, M. (2014b). Play and intrinsic rewards. In M. Csikszentmihalyi (Ed.), *Flow and the foundations of positive psychology* (pp. 135–153). Springer Netherlands. https://doi.org/10.1007/978-94-017-9088-8_10
Day, E. A., Boatman, P. R., Kowollik, V., Espejo, J., McEntire, L. E., & Sherwin, R. E. (2007). Collaborative training with a more experienced partner: Remediating low pretraining self-efficacy in complex skill acquisition. *Human Factors: THe Journal of the Human Factors and Ergonomics Society, 49*(6), 1132–1148. https://doi.org/10.1518/001872007X249983
Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*(1), 4–58. https://doi.org/10.1177/1529100612453266
Flick, U. (2019). From intuition to reflexive construction: Research design and triangulation in grounded theory research. In A. Bryant & K. Charmaz (Eds.), *The SAGE handbook of current developments in grounded theory* (2nd ed., pp. 125–144). SAGE Publications Ltd.
Flyvbjerg, B. (2011). Case study. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (4th ed., pp. 301–316). Sage.
Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059
Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2016). Student engagement, context, and adjustment: Addressing definitional, measurement, and methodological issues. *Learning and Instruction, 43*, 1–4. https://doi.org/10.1016/j.learninstruc.2016.02.002
Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: How effective are they? A meta-analysis of recent studies: Serious games as educational tools. *Journal of Computer Assisted Learning, 29*(3), 207–219. https://doi.org/10.1111/j.1365-2729.2012.00489.x
Hassanien, A. (2007). A qualitative student evaluation of group learning in higher education. *Higher Education in Europe, 32*(2–3), 135–150. https://doi.org/10.1080/03797720701840633
Heron, J. (2005). *The complete facilitator's handbook*. Kogan Page.
Hollingshead, A. B., & Brandon, D. P. (2003). Potential benefits of communication in transactive memory systems. *Human Communication Research, 29*(4), 607–615. https://doi.org/10.1111/j.1468-2958.2003.tb00859.x
Illeris, K. (2018). A comprehensive understanding of human learning. In K. Illeris (Ed.), *Contemporary theories of learning: Learning theorists... In their own words* (2nd ed., pp. 1–14). Routledge.
Iten, N., & Petko, D. (2016). Learning with serious games: Is fun playing the game a predictor of learning success? *British Journal of Educational Technology, 47*(1), 151–163. https://doi.org/10.1111/bjet.12226
Jabbar, A. I. A., & Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of Educational Research, 85*(4), 740–779. https://doi.org/10.3102/0034654315577210

Järvelä, S., Järvenoja, H., Malmberg, J., Isohätälä, J., & Sobocinski, M. (2016). How do types of interaction and phases of self-regulated learning set a stage for collaborative engagement? *Learning and Instruction, 43*, 39–51. https://doi.org/10.1016/j.learninstruc.2016.01.005

Järvelä, S., Järvenoja, H., & Muukkonen, H. (2021). Motivation in collaborative inquiry environments. In C. Chinn & R. G. Duncan (Eds.), *International handbook of inquiry and learning* (pp. 157–173). Routledge.

Kafai, Y. B., & Burke, Q. (2015). Constructionist gaming: Understanding the benefits of making games for learning. *Educational Psychologist, 50*(4), 313–334. https://doi.org/10.1080/00461520.2015.1124022

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education, 8*(1), 13–24. https://doi.org/10.1016/j.iheduc.2004.12.001

Klabbers, J. (2018). On the architecture of game science. *Simulation & Gaming, 49*(3), 207–245. https://doi.org/10.1177/1046878118762534

Knowles, M. (2015). *The adult learner: The definitive classic in adult education and human resource development* (8th ed.). Routledge. https://doi.org/10.4324/9781315816951

Knowles, M., Holton, E. F., & Swanson, R. A. (2005). *The adult learner: The definitive classic in adult education and human resource development* (6th ed.). Elsevier.

Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (2nd ed.). Pearson Education, Inc.

Kortmann, R., & Peters, V. (2021). Becoming the unseen helmsman—Game facilitator competencies for novice, experienced, and non-game facilitators. *Simulation & Gaming, 52*(3), 255–272. https://doi.org/10.1177/10468781211020792

Kvale, S. (1996). *InterViews: An introduction to qualitative research interviewing*. Sage Publications.

Lamb, R. L., Annetta, L., Firestone, J., & Etopio, E. (2018). A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations. *Computers in Human Behavior, 80*, 158–167. https://doi.org/10.1016/j.chb.2017.10.040

Lameras, P., Arnab, S., Dunwell, I., Stewart, C., Clarke, S., & Petridis, P. (2017). Essential features of serious games design in higher education: Linking learning attributes to game mechanics: Essential features of serious games design. *British Journal of Educational Technology, 48*(4), 972–994. https://doi.org/10.1111/bjet.12467

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Lewis, K., Lange, D., & Gillis, L. (2005). Transactive memory systems, learning, and learning transfer. *Organization Science, 16*(6), 581–598. https://doi.org/10.1287/orsc.1050.0143

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2018). Paradigmatic controversies, contradictions, and emerging confluences, revisited. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (5th ed., pp. 213–263). SAGE.

Lu, J., Hallinger, P., & Showanasai, P. (2014). Simulation-based learning in management education: A longitudinal quasi-experimental evaluation of instructional effectiveness. *Journal of Management Development, 33*(3), 218–244. https://doi.org/10.1108/JMD-11-2011-0115

Maxwell, J. A. (2013). *Qualitative research design*. Sage.

Mayer, R. E. (2019). Computer games in education. *Annual Review of Psychology, 70*, 531–549.

Moen, K., & Middelthon, A.-L. (2015). Qualitative research methods. In P. Laake, H. B. Benestad, & B. R. Olsen (Eds.), *Research in medical and biological sciences* (pp. 321–378). Elsevier. https://doi.org/10.1016/B978-0-12-799943-2.00010-0

Moizer, J., Lean, J., Dell'Aquila, E., Walsh, P., Keary, A., O'Byrne, D., Di Ferdinando, A., Miglino, O., Friedrich, R., Asperges, R., & Sica, L. S. (2019). An approach to evaluating the user experience of serious games. *Computers & Education, 136*, 141–151. https://doi.org/10.1016/j.compedu.2019.04.006

Muukkonen, H., & Lakkala, M. (2009). Exploring metaskills of knowledge-creating inquiry in higher education. *International Journal of Computer-Supported Collaborative Learning, 4*(2), 187–211. https://doi.org/10.1007/s11412-009-9063-y

Nadolny, L., Valai, A., Cherrez, N. J., Elrick, D., Lovett, A., & Nowatzke, M. (2020). Examining the characteristics of game-based learning: A content analysis and design framework. *Computers & Education, 156*, 103936. https://doi.org/10.1016/j.compedu.2020.103936

Nkomo, L. M. (2021). Synthesis of student engagement with digital technologies: A systematic review of the literature. *International Journal of Educational Technology in Higher Education, 18*(34), 26.

Ouyang, F., Chen, Z., Cheng, M., Tang, Z., & Su, C.-Y. (2021). Exploring the effect of three scaffoldings on the collaborative problem-solving processes in China's higher education. *International Journal of Educational Technology in Higher Education, 18*(1), 35. https://doi.org/10.1186/s41239-021-00273-y

Peltokorpi, V. (2008). Transactive memory systems. *Review of General Psychology, 12*(4), 378–394. https://doi.org/10.1037/1089-2680.12.4.378

Perttula, A., Kiili, K., Lindstedt, A., & Tuomi, P. (2017). Flow experience in game based learning—A systematic literature review. *International Journal of Serious Games*. https://doi.org/10.17083/ijsg.v4i1.151

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist, 50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Polit, D. F., & Beck, C. T. (2010). Generalization in quantitative and qualitative research: Myths and strategies. *International Journal of Nursing Studies, 47*(11), 1451–1458. https://doi.org/10.1016/j.ijnurstu.2010.06.004

Preuß, A. K. (2021). The learning process in live-action simulation games: The impact of personality, motivation, immersion, and flow on learning outcome in a simulation game. *Simulation & Gaming, 52*(6), 775–795. https://doi.org/10.1177/10468781211049822

Ravyse, W. S., Seugnet Blignaut, A., Leendertz, V., & Woolner, A. (2017). Success factors for serious games to enhance learning: A systematic review. *Virtual Reality, 21*(1), 31–58. https://doi.org/10.1007/s10055-016-0298-4

Reschly, A. L., & Christenson, S. L. (2012). Jingle, jangle, and conceptual haziness: Evolution and future directions of the engagement construct. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 3–20). Springer US. https://doi.org/10.1007/978-1-4614-2018-7

Rigby, S., & Ryan, R. M. (2011). *Glued to games: How video games draw us in and hold us spellbound*. ABC-CLIO.

Riopel, M., Nenciovici, L., Potvin, P., Chastenay, P., Charland, P., Sarrasin, J. B., & Masson, S. (2019). Impact of serious games on science learning achievement compared with more conventional instruction: An overview and a meta-analysis. *Studies in Science Education, 55*(2), 169–214. https://doi.org/10.1080/03057267.2019.1722420
Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.
Sawyer, R. K. (2004). Creative teaching: Collaborative discussion as disciplined improvisation. *Educational Researcher, 33*(2), 12–20. https://doi.org/10.3102/0013189X033002012
Sawyer, R. K. (2017). *Group genius: The creative power of collaboration*. Basic Books.
Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2017). Computer-based technology and student engagement: A critical review of the literature. *International Journal of Educational Technology in Higher Education, 14*(1), 25. https://doi.org/10.1186/s41239-017-0063-0
Schuurman, P. (2017). Models of war 1770–1830: The birth of wargames and the trade-off between realism and simplicity. *History of European Ideas, 43*(5), 442–455. https://doi.org/10.1080/01916599.2017.1366928
Schwägele, S., Zürn, B., Lukosch, H. K., & Freese, M. (2021). Design of an impulse-debriefing-spiral for simulation game facilitation. *Simulation & Gaming*. https://doi.org/10.1177/10468781211006752
Schwandt, T., & Gates, E. (2018). Case study methodology. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (5th ed., pp. 600–630). SAGE.
Schwarz, R. M. (2017). *The skilled facilitator: A comprehensive resource for consultants, facilitators, coaches, and trainers* (3rd ed.). Jossey-Bass.
Super, J. F., Betts, T. K., Keller, H., & Humphreys, J. R. (2020). Simulation game outcomes: A multilevel examination of knowledge sharing norms, transactive memory systems, and individual learning goal orientations. *Simulation & Gaming, 51*(6), 830–858. https://doi.org/10.1177/1046878120943255
Taylor, A.-S.A. (2014). *Facilitation matters: A framework for instructor-led serious gaming*. University of Skövde.
Timmermans, S., & Tavory, I. (2012). Theory construction in qualitative research: From grounded theory to abductive analysis. *Sociological Theory, 30*(3), 167–186. https://doi.org/10.1177/0735275112457914
Van den Bossche, P., Gijselaers, W. H., Segers, M., & Kirschner, P. A. (2006). Social and cognitive factors driving teamwork in collaborative learning environments: Team learning beliefs and behaviors. *Small Group Research, 37*(5), 490–521. https://doi.org/10.1177/1046496406292938
van der Meij, H., Albers, E., & Leemkuil, H. (2011). Learning from games: Does collaboration help?: Learning from games. *British Journal of Educational Technology, 42*(4), 655–664. https://doi.org/10.1111/j.1467-8535.2010.01067.x
van der Meij, H., Veldkamp, S., & Leemkuil, H. (2020). Effects of scripting on dialogues, motivation and learning outcomes in serious games. *British Journal of Educational Technology, 51*(2), 459–472. https://doi.org/10.1111/bjet.12851
van Roy, R., & Zaman, B. (2018). Need-supporting gamification in education: An assessment of motivational effects over time. *Computers & Education, 127*, 283–297. https://doi.org/10.1016/j.compedu.2018.08.018
Vandercruysse, S., & Elen, J. (2017). Towards a game-based learning instructional design model focusing on integration. In P. Wouters & H. van Oostendorp (Eds.), *Instructional techniques to facilitate learning and motivation of serious games* (pp. 17–35). Springer. https://doi.org/10.1007/978-3-319-39298-1
Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education, 14*(1), 22. https://doi.org/10.1186/s41239-017-0062-1
Wang, Y., Rajan, P., Sankar, C. S., & Raju, P. K. (2017). Let them play: The impact of mechanics and dynamics of a serious game on student perceptions of learning engagement. *IEEE Transactions on Learning Technologies, 10*(4), 514–525. https://doi.org/10.1109/TLT.2016.2639019
Westera, W. (2015). Games are motivating, aren´t they? Disputing the arguments for digital game-based learning. *International Journal of Serious Games*. https://doi.org/10.17083/ijsg.v2i2.58
Westera, W. (2019). Why and how serious games can become far more effective: Accommodating productive learning experiences, learner motivation and the monitoring of learning gains. *Educational Technology & Society, 22*(1), 59–69.
Wong, M. M., & Csikszentmihalyi, M. (1991). Motivation and academic achievement: The effects of personality traits and the quality of experience. *Journal of Personality, 59*(3), 539–574.
Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology, 105*(2), 249–265. https://doi.org/10.1037/a0031311
Wouters, P., & van Oostendorp, H. (2017). Overview of instructional techniques to facilitate learning and motivation of serious games. In P. Wouters & H. van Oostendorp (Eds.), *Instructional techniques to facilitate learning and motivation of serious games* (pp. 1–16). Springer. https://doi.org/10.1007/978-3-319-39298-1
Yang, J. C., & Quadir, B. (2018). Effects of prior knowledge on learning performance and anxiety in an English learning online role-playing game. *Educational Technology & Society, 21*(3), 174–185.
Zambrano, J., Kirschner, F., Sweller, J., & Kirschner, P. A. (2019). Effects of prior knowledge on collaborative and individual learning. *Learning and Instruction, 63*, 101214. https://doi.org/10.1016/j.learninstruc.2019.05.011
Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade. *International Journal of Computer Games Technology, 2019*, 1–8. https://doi.org/10.1155/2019/4797032

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