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Article

The emergence of collaboration in serious games: An exploratory study

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Abstract

The use of collaboration as an approach to learning is pervasive both in work and education, and it is commonplace for serious games to employ collaboration. Collaboration in serious games may enhance learning and provide players with an engaging and enjoyable experience. However, collaboration is often taken for granted in research, neglecting to account for between-group variance and how collaboration emerges. This exploratory study aims to improve understanding of how collaboration emerges during play by investigating experiences and actions believed to foster collaboration. To achieve this, 69 students were studied across two separate sessions, one digital and one physical, in groups of 3-5. We observed both sessions and conducted 13 in-depth interviews. The findings of the study indicate that the emergence of collaboration relies on cognitive management of difference mindsets, individuals adapting to group strengths and weaknesses, and joint goal-directed play. We find that serious games can create unique ways for collaboration to emerge not found in non-game collaboration, which may positively influence learning under the right conditions. Our findings provide insight into some such conditions, but further research is needed to improve understanding of what these conditions are and how to reach them.

1. Introduction

Collaboration is a pervasive approach to learning in education [1] and work [2], believed to be a fruitful supplement to solitary learning when creativity, adaptability, and complex problem-solving is necessary [3], [4], [5]. Collaboration can be defined as distributed-responsibility group work towards a shared task and goal, where expertise and knowledge are shared and constructed [6]. For collaboration to occur, however, groups must mature and learn how to work together productively and effectively [7], [8]. Groups that develop *psychological safety* (mutual trust and respect), *task cohesion* (shared goal commitment), *potency* (perceived group effectiveness), and *perceived interdependence* (of tasks and outcome benefits) may attain mutual understanding and shared cognition [6]. Such qualities are referred to as *emergent*

states, i.e., dynamic team properties that vary due to setting and context [9]. In *serious games*, games designed to afford learning, playing in collaborative groups is an established practice [10], believed to create engaging and enjoyable play experiences [11]. Recent meta-analyses posit that collaboration may positively impact learning in serious games [10], [12], particularly when learning entails problem-solving [13], handling of complex tasks [14], discussion and negotiation [11], [15], and applying previous experience and knowledge [14]. Furthermore, adaptive facilitator support [16] and scripts/instructions that stimulate communication [17] seems to enhance learning outcome in collaborative groups. However, the conditions for and outcomes of collaboration in serious games remain underexplored.

In our review of existing research literature, we find that studies of collaboration in games are characterized by inconsistent use of terms and definitions. Terms such as teams, groups, collaboration, cooperation, and social play are variably applied, referring to the same, different, or related phenomena [2], [18]. Moreover, how these terms are employed is often not explicated. In a meta-analysis by Wouters & van Oostendorp [10], for instance, less than half of group play studies explained how and why participants were playing together. Similarly, in a review by Wang & Huang [12], <40% of collaborative serious game studies employed a model or theoretical framework for collaboration. This makes cross-comparison difficult, slows down the development of knowledge on the topic [19], and obfuscates the state of existing understanding. We find that there are three interrelated knowledge gaps which seem especially pertinent as limiting factors for current understanding of how collaboration comes to be and plays out during serious game play:

First, *how contextual conditions impact collaboration during play is underexplored*. The evidence in favor of collaborative serious games promoting learning is growing robust. However, the majority of research on the topic focuses on *outcomes* of play, relying on quantification of collaboration and learning through questionnaires and knowledge testing (e.g., [10], [12], [20]). This provides insight into the occurrence and outcome of collaboration but is not well equipped to explore why and how participants engage in collaboration, how they experience it, or how collaboration matters to learning. Thus, such research does not account for how different contexts (e.g., player age, medium, topic, duration) shape collaboration *during* play, and the role this may have for the later outcome [21], [22].

Second, *current research lacks nuance regarding how collaboration happens in play*. Groups develop over time, gradually improving their relationships and ability to collaborate [8]. However, collaboration is commonly treated as something that is or is not occurring in serious game research, based solely on whether participants can interact. Employing this approach neglects to account for the emergence (i.e., how it comes to be and develops) and enactment of collaboration and the role of individual players in creating possibilities for collaboration to emerge (e.g., [11], [12], [23]). This suppresses understanding of qualitative and quantitative differences within collaboration and neglects that interaction can occur without it classifying as collaboration [24]. Considering that games are complex, context-dependent, and multidisciplinary artefacts [25] made up of multifaceted relationships [23], such insight is necessary to fully understand collaboration during play.

Third, *collaboration variations are rarely reported in research*. How collaboration happens within groups is often not stated in collaboration research generally [26] and in serious games research specifically [27], [28]. Research also indicates that even when group composition and tasks are constant – which is difficult to achieve in games [25] – between-group outcome variation is prevalent [6]. Thus, collaboration emergence during play likely varies between groups due to, e.g., individual differences, relationships, facilitation, and game, and how realization of such possibilities vary between individuals and groups is underexplored in research. This encompasses both how the game and play setting creates a need for, e.g., shared task conception, interdependence, and sharing expertise [6], [29], and how individuals and groups varyingly foster their emergence.

The aim of this study is to improve upon the postulated research gaps by investigating experienced collaboration in a serious game as it develops. We explore the experience of collaborative play to get insight into how collaboration emerges, and how group-level variation in collaboration comes to be. To achieve this, we apply a qualitative research design, using observations and player and facilitator interviews to get insight into a play situation from different and complimentary vantage points. By using a qualitative approach we aim to attain an in-depth and nuanced understanding [30] that accounts for individual differences, rather than strive for homogeneity and generalizability [31]. To accomplish these aims, the study is conducted in pursuit of the research question *"How does collaboration emerge during a serious game?"*. Answering this may contribute to knowledge regarding the conditions under which collaboration occurs, complementing previous research linking play and collaboration. This may also advance collaborative serious game knowledge through comparison to non-game contexts, interpreting the emergence of collaboration in light of play.

2. Methods and Material

2.1 Game Design and Background

The investigated game consisted of a game board, card decks with prompts and actions, and sticky notes used for tracking decisions and progression throughout play. The objective of the game was learning how to apply theoretical understanding of intellectual property (IP) and IP rights (IPR) (e.g., copyrighting, trademarking, and patenting, for business strategy decision-making) practically. The game followed a fictitious narrative of a startup company with a novel product idea, which realization requires tackling several IPR challenges – intended to simulate the reality of such a company authentically, in a way that is usable outside of the game. To achieve this, players had to draw on their joint existing experience and knowledge, working together collaboratively against the game system. The rules of the game restricted interaction with the game to some extent (e.g., players could not disregard explicit narrative details or determine the outcome of game happenings), but players were largely free to use fantasy and creativity to expand on the narrative, creating a story for themselves, and solve the challenges posed accordingly. As such, the game provided an open, flexible, and consequence-free interaction environment, wherein player groups could safely discuss, reflect, and experiment, adapting play to their preferences, experiences and competences, in pursuit of a common goal.

The game consisted of two phases. In the first phase, information was provided to the player groups, from which they had to discuss and make decisions about their roles, goals, and the product – creating a strategy for IP/IPR. The drawing of information cards (e.g., opportunities, competition, environment) guided progression. The aim of the first phase was to create an understanding of the practical application of IPR and to initiate collaborative processes. In the second phase of the game, ill-structured challenges were introduced. These challenges were open-ended with little restriction on possible solutions. One simplified example is: "*NASA approaches you with a collaboration opportunity – discuss consequences and opportunities and decide on a course of action*". The challenges were presented chronologically, building on each other, so that solutions and decisions have consequences for the development of the narrative and subsequent action opportunities. The aim of this phase was the practical application of relevant knowledge to make decisions and solve problems collaboratively. Creating and applying an IP/IPR strategy that handles all the challenges faced represents the winning condition for the game. See figure 1 below for a graphical representation of game progression. After the game, a debrief session was carried out with a subject matter expert to strengthen theory-practice connection.

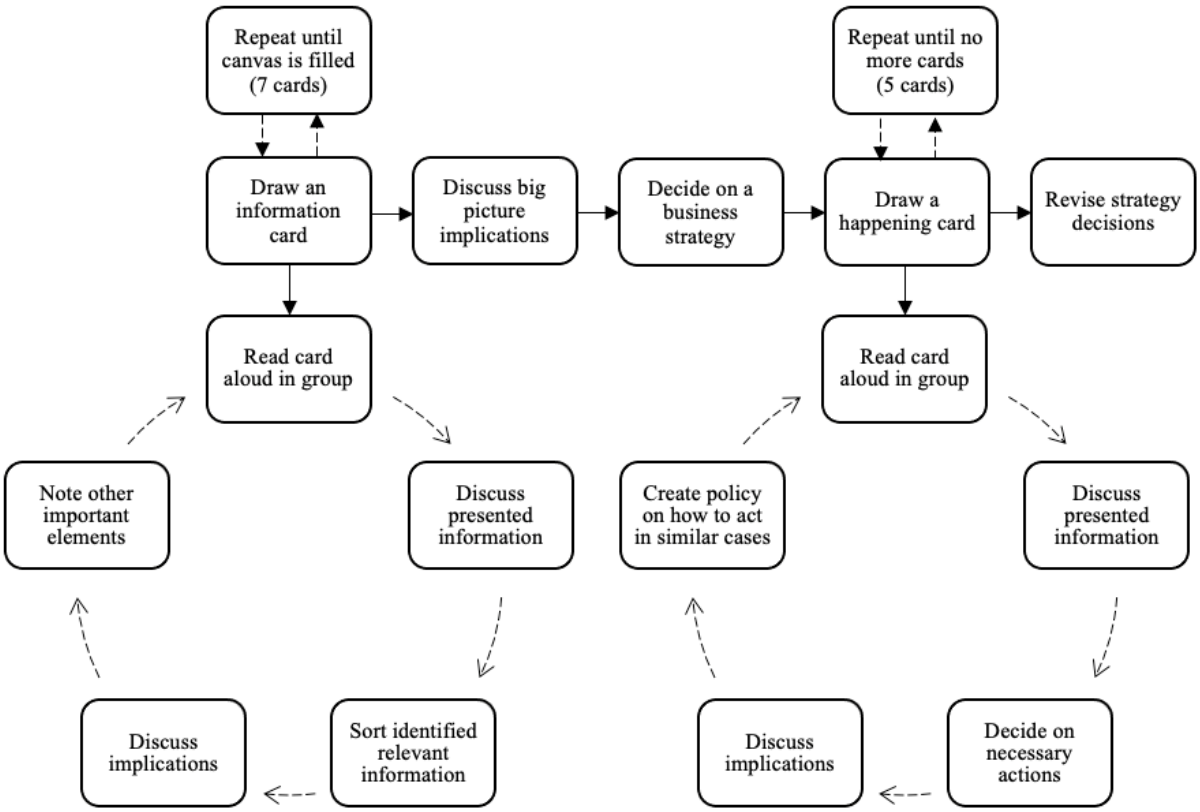

Figure 1. Progression of gameplay in the studied game.

2.1.1 Game Task Typology

To account for the learning tasks of the game, it is useful to introduce a *task typology* – a framework for understanding the characteristics of the tasks players carry out [32] during play. This provides an indication of the games for which findings are likely to be most relevant or transferable – those that share the same or similar characteristics. For instance, as this is a collaborative game, results are unlikely to be transferable to single-player game learning and may be only partially relevant in competitive games. We draw on the task typology of Mitchell and Carbone [32], which provides eight dimensions of tasks influencing learning:

- *Routine – Novel*: The degree to which the activity of the task is new to the learner(s). For the players in this study, the game task was considered **novel**.
- *Artificial – Authentic*: Artificial tasks are constructed for schooling, whereas authentic tasks approximate what is being done in the real world and has practical relevance outside of the learning activity. The investigated game is intended to be as **authentic** as possible.
- *Closed – Open*: Open tasks give learners choices to make, whereas closed tasks do not. The investigated game is highly **open**, both in possible approaches and outcomes.
- *Degree of Ownership*: The degree to which learners have input or control over formulation of the task, the way it is handled, and the way it is assessed. The investigated game falls in the middle on ownership, as players do not have input on formulation, but have substantial control over handling and assessment.
- *Degree of Linkage*: The degree to which tasks inspire mental connections to prior knowledge and experience. This depends on the individual, of course, but the game provides ample opportunity for players to draw on existing knowledge and experience, connecting it to novel insight gained during play.
- *Degree of Reflection on Learning*: The extent to which tasks inspire self-reflection or metacognition. The investigated game does this to some extent by encouraging reflection

on tasks and how to solve them, and the use or value of outcomes, but does not explicitly facilitate learning to learn (better).

- *Individual – Collaborative*: The degree to which a task promotes and/or requires interdependent (mutually reliant) collaboration. The investigated game is **collaborative**, with a high degree of interdependence in decision-making and problem-solving.
- *Simple – Complex*: The amount of information to consider, number of steps needed to reach a solution, and number of goals to achieve. The open-ended tasks in the game are **complex** regarding information/possibilities to consider, but rarely require many steps, and are presented one (goal) at a time.

2.2 Play and Player Context

In total, 69 players participated in two discrete play sessions. The sessions took place at a Central European university, and all participants were graduate students attending a course/unit on technology management. The game was conducted in English, accommodating national diversity in the student group. Participants had varied academic backgrounds, but industrial engineering, sustainability, IT, and various forms of management were common. As such, the majority of participants had limited or no expertise on the topic of the game but were knowledgeable in fields of study where IP and IPR are important. The participants were assigned to groups of 4-5 at the beginning of the course, and these were the same groups they played the game in. Groups had previously worked together on one group assignment, so they had some limited background knowledge about each other's expertise and interaction preferences but were not well acquainted. Play happened on-site at the university (32 participants) or online using video communication and a digital version of the game (37 participants). The role of the game in the course was to connect theoretical knowledge (from previous lectures) to practical application on the topics of IP/IPR and strategy management. Facilitators and a subject matter expert were present throughout the play sessions to aid participants both with content questions and collaboration. Play lasted approximately six hours. Furthermore, participants underwent some preparations before playing. They were offered an e-learning program on relevant topics to ensure adequate theoretical knowledge and a practice-minded lecture by a subject matter expert.

2.3 Data Collection

For this study, two forms of data were collected – observations and interviews. Figure 2 below depicts the data collected for the study.

Observational data were collected during play, by watching and listening to participants. The observation approach was used to get an unmediated look at how participants act and interact, albeit from an outsider perspective [33], providing indications of how the game was experienced. Quick notes (i.e., keywords and short sentences) were taken throughout the sessions, focusing on observable action and interaction relevant to collaboration, engagement, and learning dimensions. This was done to keep track of important observations and were later used for writing more coherent fieldnotes detailing what transpired during play [34]. Fieldnotes created from play observations were then used to situate and contextualize player experiences. Observations contribute to answering the research question directly, yet the chief reason for using observations is to support interview data, as using a mixed methods approach strengthens interview studies [35].

Interviews were conducted after play. Prior to play, we informed participants about the proposed study and the need for interviewees – requesting those willing to be interviewed to provide their contact details. After play concluded, we reached out to several participants by

mail to provide detailed information about the research. We recruited 13 interviewees in total, 10 participants and 3 facilitators to contextualize participant experiences, of which 5 were women and 8 were men. The recruited participants all belonged to different player groups, providing insight into diverging perspectives and experiences between groups. Like with the larger student group, interviewed players represented diverse nationalities and had varied academic backgrounds and expertise, with 4 interviewees in industrial engineering, 2 in sustainable management, 2 in IT management, and 1 each in electrical engineering and political science. All interviews were carried out online using video communication in the weeks following the play sessions. A semi-structured interview approach was used, i.e., open questions guided a conversation around relevant, predetermined topics. Since the study is exploratory, questions were formulated to enable interviewees to explain their experience and tell their story – as opposed to providing specified information [36]. The interview guide contained questions such as "did you take on a specific role in your group?" and "how did you deal with disagreements?". The in-depth interviews lasted up to 90 minutes and were recorded and transcribed verbatim.

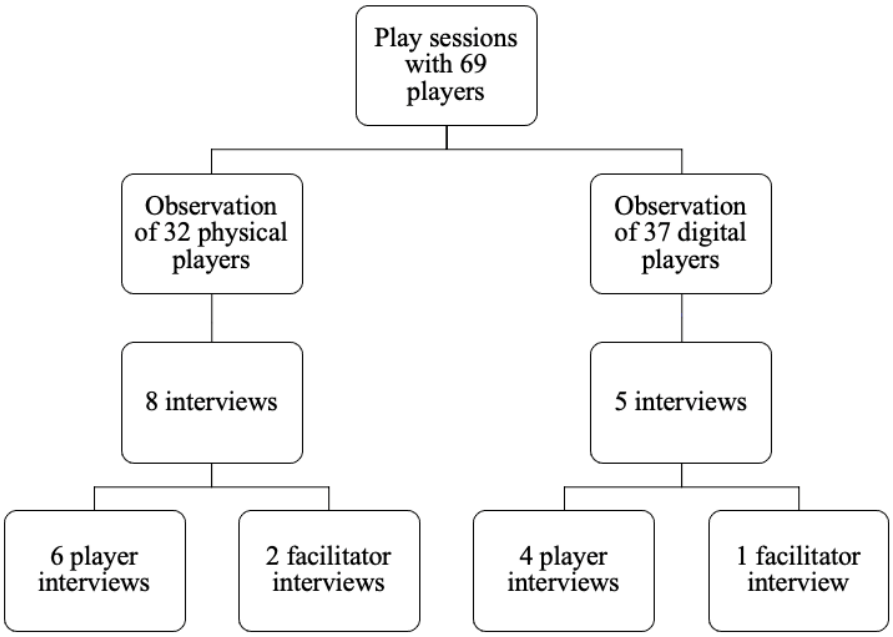

Figure 2. Overview of collected data.

2.4 Data Analysis

The data analysis applied was based on some, but not all, major principles of *constructivist grounded theory* [37], an inductive data analysis approach that supports exploratory analysis without relying on, or intending to confirm, a predetermined theoretical framework. Instead, sensitizing concepts – concepts that guide topic choice, spark thinking, and inspire novel ideas – are used as a point of departure [35]. This fits well with the exploratory aims of the current study, which applied collaboration and learning as sensitizing concepts. An additional benefit of this approach is that analytical strategies can be adapted to the needs and possibilities of research projects [38]. For instance, it would not be within the scope of possibility for this study to engage in theory construction, due to the exploratory aims of the study and breadth of the topic. Thus, we crafted an analytic approach fitting the exploratory objectives of the study which entailed the following steps:

The first analytical step was a *line-by-line coding*, i.e., labeling bits of data at the lowest meaningful level (i.e., sentence or clause) to make analytic sense of actions and experiences, and initiate conceptual development [35]. An example of this is the interview statement "*it wasn't, like, a problem to say, 'I don't think that matches up' or maybe 'I see that differently'*" being coded as "*perceiving group atmosphere as open*". A total of 1075 codes were applied at this stage.

Second, line-by-line codes were coded anew using *focused coding*, i.e., separating, sorting, and synthesizing frequent and analytically significant codes by comparing within and between them. This entailed making decisions about how to categorize codes incisively, in a way that makes analytic sense [35]. The example statement above was coded as "*perceiving group as safe*" at this stage, alongside codes such as "*admitting to mistakes*" and "*feeling comfortable voicing opinions"*. Focused coding reduced the number of codes to 65.

Third, focused codes were sorted into 12 preliminary categories created by comparing data and exploring connections, which were subsequently used for *memoing*. Memoing entailed writing descriptive and analytical notes about categories, based on codes that convey meaning and action. This offers a space for taking codes apart and analyze them by making comparisons and exploring ideas [35]. The example statement was included in a preliminary category called "*from individuals to a team*". Out of these categories, five were excluded from further analysis due to irrelevance to the research topic.

Finally, categories that cover related topics were merged into broader conceptual categories, for a total of three overarching, conceptual categories. The example statement ended up in the conceptual category "*collaboration emerging through taking action to adapt to the group*". For a visual representation of the analytic steps, see figure 3 below.

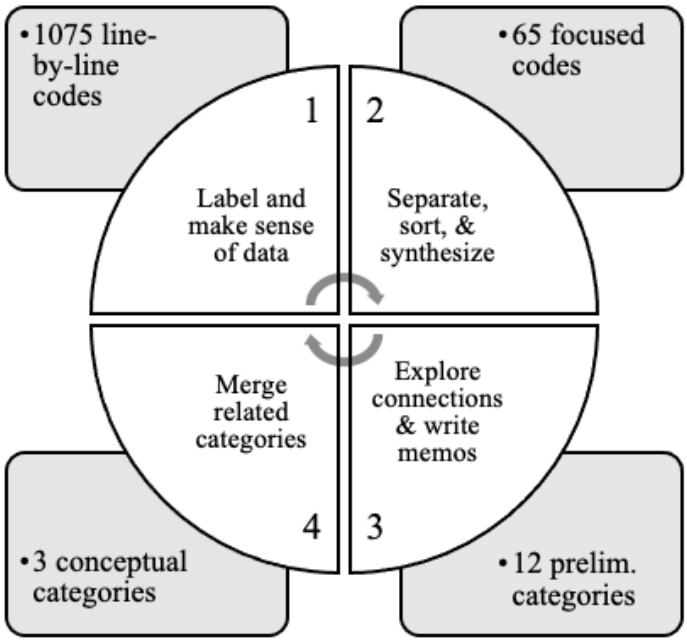

Figure 3. The four main steps of data analysis.

3. Results

To reiterate, the research question guiding this study is "*How does collaboration emerge during a serious game?"*. In this chapter, we first present the study's contextual foundation, recounting the observations that incited posing the research question. Then, we present our analysis of

observations and interviews to better understand what we observed and further explore the emergence of collaboration. Findings are based chiefly on interview data – presented using interview excerpts and analytical commentary – supported by complementary insights from observations.

3.1 Contextual Foundation

During our first observation, it became apparent that participants were having fundamentally different experiences of play. Most participants seemed to be engaging with the topic, enjoying play, and collaborating well. However, some were quiet and seemed disinterested. No one actively protested, but it was noticeable from their body language and silence that they were not enjoying themselves. We found it unlikely that these individuals/groups engaged in collaboration. These varied experiences arose despite the participant population being rather homogenous. They all played the same game, supported by the same facilitators, and were all of similar age, there was no gender imbalance, they were not graded or rewarded, they all attended volitionally. Furthermore, they were all students at the same university enrolled in the same course, having received the same pre-game instructions, and were randomly assigned to groups. Despite these key similarities, there had to be a reason why some individuals/groups were enjoying the experience more. This was our starting point – understanding why some participants thrived when others did not. We had some inklings as to why this was, chiefly pertaining to team composition, team dynamic, and individual differences. In other words, we believed there would be some combinations of traits fostering the emergence of collaboration, and that only groups able to work together collaboratively would learn during play and enjoy the experience. Seeing as we did not know what to look for – and existing research provided few answers – we decided to carry out exploratory interviews to get insight into participant experiences and reflections.

3.2 Exploring the Emergence of Collaboration

Here we present our findings from analyzing how collaboration emerges during play. To structure these findings, we created three overarching conceptual categories – *collaboration emerging through management of individual differences*, *collaboration emerging through taking action to adapt to the group*, and *collaboration emerging through play towards a common goal* – each representing interrelated fragments of what it took for collaboration to emerge. P1-P13 are used in lieu of participant names when interview excerpts are presented.

3.2.1 Collaboration Emerging Through Management of Individual Differences

A key takeaway from the observations above was that how participants experienced interaction differed drastically. We interpret these different patterns of interaction as grounded in discovery and cognitive framing of individual differences (preferences, values, personality traits, etc.), in a one-on-one process of difference management impacting the emergence of collaboration. This notion was supported by interviewees' characterizations of their group members, for good and bad. On the positive side, interviewees recount recognizing what they construe as others' strengths, reflecting on how that shaped interaction experiences (e.g., "*she is really an analytic person … sometimes I'm surprised by her thoughts as they are really deep and thought-through*", P10; "*he is not afraid of asking questions…and I think it helped [progression]*", P8). Playing together thus seems to facilitate both the discovery of others'

strengths and realizations of how collaboration improves by exploiting differences. As such, collaboration can emerge when participants learn about and utilize others' strengths.

However, interviewees also reflect on managing individual differences construed negatively. We observed two different approaches to this, influencing experienced collaboration. First, in a process of *reframing*, interviewees reflect on construing positive sides to differences initially negatively evaluated. For instance, P9 explains that *"…she got a bit stubborn about [an idea] and it was a bit tricky to work our way around that*". The interviewee then elaborates on how they aimed to reach agreement, recalling that "*what she said was insightful too and there were new perspectives […] it was helpful to elaborate on new ideas [and] we also need to be a bit creative and think outside of the box*". We interpret this as an example of reframing a negative construal (stubbornness) into a positive (creativity) by having an open and adaptive mindset. Through reframing, collaboration experiences become more likely. Games offer a suitable setting for reframing as there is no singular, correct way to act or think, making different play approaches viable. The other approach to managing difference was *coping*. For instance, P8 said about a teammate "*he has many ideas, but I don't think he is able to structure them, so it was a little difficult, we were constantly talking".* In this case, the negatively construed trait was seen as something to be negated. Participants employing a coping approach seem unwilling or unable to adapt to differences yet are willing to make do. We argue that managing negatively construed differences without adaptation may not contribute to the emergence of collaboration, but it might not hurt either. Still, the malleability of games could provide opportunity for subsequent reframing at later stages.

Furthermore, we interpret management of differences as produced in interaction – traits construed as negative by one participant could often be perceived as positive by another with equal soundness. For instance, passivity was mentioned by some as a negative trait. However, what was perceived as passivity could also be perceived as reflectiveness – a participant with a quieter disposition might come off as passive in a loud group. We observed groups who seemed passive at first glance yet seemed to be engaging deeply in play. We interpret this, too, as a form of dealing with individual difference, as groups constructed a form of interaction fitting for everyone.

In sum, collaborative games make individual differences come to light, for good and for bad. In games, most traits can be accommodated and construed as strengths, but whether that happens or not depends on the individuals in the group. A willingness to look for strengths in individual differences seems to foster emergence of collaborative experiences. Thus, individuals and groups that evaluate differences positively and accentuate each other's strengths will be better equipped to act and learn collaboratively.

3.2.2 Collaboration Emerging Through Taking Action to Adapt to the Group

The individual differences initially discovered and evaluated must also be acted upon for collaboration to emerge. This includes learning who knows what and taking action to adapt to group members' preferences and needs. A necessary antecedent to this is getting acquainted, which may occur during play. Participants describe how they got acquainted during play, both concerning cognition ("*I developed a sense of what are their specialties maybe and what they're good at*", P3) and on an interpersonal level ("*I got along with them well… there was no real problem there*", P11; "*this game […] really helped in the group work, I think we were really successful in that*", P7). In both cases, we argue that getting acquainted facilitates emergence of collaborative experiences. Considering groups had briefly worked together previously yet experience play as forming acquaintance, we argue acquaintance can be driven by play enabling novel forms of interaction not occurring naturally or regularly elsewhere.

One way in which participants put acquaintance to use is through the adoption of informal roles. For instance, P8 experienced a group member as creative and talkative, yet in need of

structuring to progress. They recall that "*We were just constantly talking [which] is good but talking must also be productive. [So,] I was constantly like 'we only have five minutes, we have to concentrate'… I think with the moderation it functioned pretty well [and] I think that was pretty much the key for us*". We interpret this as becoming aware of group members' abilities, followed by taking on a specific role to harness strengths whilst curbing weaknesses. P4 also recounts their experience adapting in an interdisciplinary group: "*[acting] more as the moderator sometimes, trying to connect different perspectives and I provided [insight on] what would be possible*," – discovering a missing link and adopting a role to fill that gap. Discovering missing links may happen when games stimulate participants to act differently from what they normally would, making group needs easier to spot. Furthermore, participants are not forced into a particular role or interaction pattern, enabling participants to adapt as they see fit.

Another experience we interpret as part of taking adaptive action is the handling of knowledge and experience diversity in the group. Several participants recognized the importance of diversity, such as P10, who stated "*it helped because [the discussion] was not narrowed down to a technical perspective only… we looked sometimes from two angles on it*" and P5 "*for me it was good to see the different thinking from the other students, they have a different background … that diversity in the group I think helps a lot to find a good solution*". In the process of adaptation, participants that perceived diversity as opportune rather than threatening or confounding, were subsequently able to incorporate diverse perspectives and understandings in their problem-solving and collaboration. As such, we argue that incorporation of everyone's knowledge in play fosters the emergence of collaboration. Play without adaptation is possible, but collaboration and learning may suffer if detached from prior knowledge. Perceiving diversity as beneficial may thus improve collaboration generally and problem-solving specifically. Because participants perceive diverse cognition as coming to the fore during play, we argue that the game setting promotes application of diverse experiences and knowledges.

In sum, actions facilitating adaptation includes getting to know each other better, taking on roles that enable the emergence of collaboration, and using diverse experience and knowledge during play. We understand the process of adaptation as a continuation of managing differences cognitively, where group level processes may rectify negatively construed individual differences.

3.2.3 Collaboration Emerging Through Play Towards a Common Goal

Participants had to engage in problem-solving and decision-making to progress in the game, requiring collaboration to reach agreements/solutions. This category details experiences of playing and working together towards common goals, and how that fostered emerging collaboration.

First, novelty seems to drive the emergence of collaboration because the game was unfamiliar to participants. They had to figure out together how to approach it and face its challenges. We observed this in how groups initially spent time familiarizing with the board. P9, for instance, explains an experience of initial challenge: "*at the beginning it wasn't quite clear what we were doing […] if you don't know if you're heading in the right direction that's just… you feel uncomfortable and you don't enjoy it as much"*. However, to proceed participants had to grapple with this together. P9 continues "*[later on] learning by doing, we understood what the aim was. […] When we were having the scenarios and discussing it […] we had a lot of fun and us in the group, the discussions were more fruitful […] But obviously, you need to do the first part to understand the situation"*. P8 shares this sentiment, stating that "*after [the first] couple of cards we just, like, got the idea, like 'okay we should do this and that' […] at the end I was very engaged in the game*". We interpret this process of facing a

challenge and overcoming it together as necessary for collaboration to emerge, as intragroup interaction is tested, and members learn about each other's collaborative preferences and approaches.

Second, participants recount how they collectively developed strategies to solve problems and progress. P11, for instance, explains that "*when someone presented their idea, the other two would basically say if they had also thought in that direction or not. And then we looked at what we had already written down, to see if we could apply it to any of that… it was just like a 'free idea zone' basically, everyone could add input and you didn't get any pushback*". This group collaboratively decided that they would emphasize equal participation and creativity, rejecting the search for one, simple solution. P7 also recounts applying a strategy to make decisions collaboratively when new information arises: "*Everybody [wrote] the most important things [to them], and we started discussing… and then from this information, what kind of decisions might make sense".* Participants recognize that such collaborative strategies were needed to complete the game – and to enjoy playing it ("*I think if I would have had to do the game by myself, I might not have had so much fun, but because I was able to discuss the hurdles…it was very nice*", P9; "*I can't do it on my own, and I have to get in a constant loop with my partners to decide on, and also to argue about, what we learned and how to elaborate on the situations", P10*). Creating strategies can be interpreted as a result of getting acquainted and adapting to the group, but also as a collaborative experience of reinforcing the emerging collaboration through shared practices. The openness and flexibility of play enabled groups to approach problems in their preferred manner, meaning they had to figure out how everyone in the group preferred to interact. This contrasts non-game settings, where a single approach can often be predetermined for problem-solving, decision-making, or other important aspects of collaboration.

In sum, applied collaborative practices may foster the continued emergence of collaboration. Collaboration is not something that comes to be and then *is*, but rather something that continuously emerges. Thus, the hurdles groups must face to progress can both reinforce existing collaborative practices and enable the emergence of novel collaboration forms.

3.3 Category Interrelation

We interpret the three presented categories as interrelated and mutually dependent steps of a process, albeit with a significant amount of variation between individuals within them. We argue that for a collaborative experience to occur and develop during play, participants had to experience each of these steps. What also becomes apparent when interpreting the categories as a process is that each represents a different form of thinking and acting – the first is an internal cognitive process, the second represents external individual action, and the last shows shared collaborative action. This demonstrates how individual differences may guide collaborative play and why game collaboration should be interpreted as a dynamic, emergent phenomenon. Furthermore, this also makes it clear that while the steps do seem to follow each other, this does not happen linearly – the two first steps may occur after shared action is initiated. Figure 4 below presents the three categories sequentially, along with the most important experiences for each.

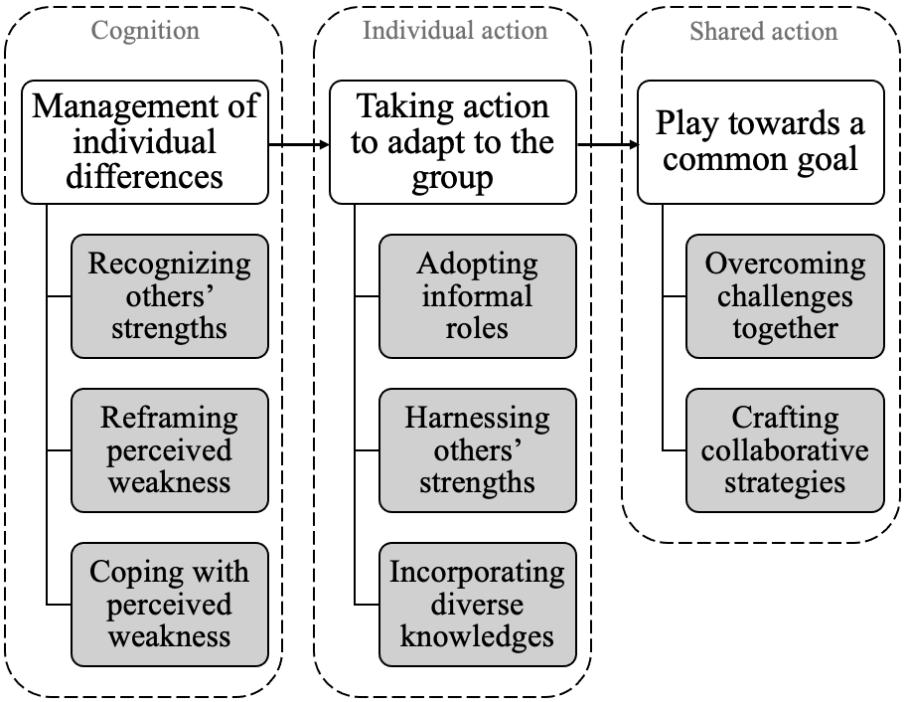

Figure 4. Interrelation of categories and their central experiences.

4. Discussion

In this study, we found that participants experienced cognitively managing differences, adapting to the group, and joint goal-directed play as shaping whether and how collaboration emerges and develops over time in an interrelated process**.** In this chapter, findings are discussed in light of existing research to garner further insight into how collaboration may emerge and how games (with similar task characteristics as the studied game) may create a unique context for emergence and enactment of collaboration. The study contributes to existing literature in four distinct ways.

First, the experience of emerging collaboration seems to depend on participants' mindsets, employed to cognitively evaluate and manage differences (e.g., preferences, values, traits) between themselves and group members. Mindsets may contribute to understanding the significant between-group variation [6] which is commonly found in game collaboration research [10]. This is in line with previous findings on the topic of *team composition* in non-game contexts [39], including that individual traits may significantly impact the performance of the whole group [40], [41]. Previous research on traits supports the notion *that* individual mindsets impact collaboration, as team performance hinges on collaboration [2], [39], but does not specify *how*. We argue that this study expands understanding of between-group variation by proposing that specific mindsets of difference evaluation and management may foster the emergence of collaboration. These findings have practical implications for the facilitation of games, as facilitators may help groups or individuals that struggle with this by pointing out how differences can entail complementary skills and knowledge. Considering differences and team composition in the debriefing phase of a play session may also be valuable for players, especially if collaboration functioned poorly.

Building on this, how does play matter to the application of difference evaluation and management mindsets? We argue that games are particularly useful arenas for discovering and evaluating differences, as play pushes participants into novel forms of action requiring mutual reliance for solving complex tasks [21], [39], [42], which may reveal differences that would otherwise remain hidden. Play is also open and variable, shaped by the players with no unilaterally correct approach to interaction, allowing evaluations and interactions to emerge between people [21], [25]. This creates an environment where most perspectives, behaviors, and traits can fit in, enabling varied strategies to manage difference. From a game design perspective, it may be fruitful to implement elements in the game that aid players in discovering the value of differences. For instance, problem solving efforts could be designed to encourage reflection on diverging perspectives whilst requiring application of a broad skillset.

Second, we found that participants experienced gradually transitioning from getting acquainted (cognitive management) towards adapting to others (taking individual action). Doing so entails a willingness to figure out what others know, form an understanding of who knows what, and look for ways to act that complements others' knowledge, for the joint benefit of the group. This finding contributes to understanding how preconditions for *shared cognition* (structures of collective meaning), a constitutive part of collaboration [2], emerges. We argue that this form of adaptive action can be interpreted as facilitating *co-construction of meaning*, "a mutual process of building meaning by refining, building on, or modifying [statements]" [43, p. 287], necessary for achieving shared cognition. We interpret adaptive action as antecedent to co-construction, where adoption of roles creates an environment promoting construction and co-construction of meaning and knowledge. Furthermore, this may also be interpreted as constituting a *swift* emergent state – i.e., development of emergent states in the initial phases of a group's life, which differs from their longitudinal counterpart. This is an under-researched topic [26] to which findings of this study may contribute greater understanding.

Shared cognition has received some attention in game research previously [44], [45], [46] and our findings indicate two related ways in which these experiences may be more likely to emerge during play than in other contexts. For one, participants follow a narrative which makes available different positions to fill and different tasks to accomplish [47], [48]. This, combined with play being open and variable [21], creates a range of action possibilities and roles, fit for diverse knowledge and experience backgrounds. The narrative and the positions the game enables could make it easier for participants to accept positions they would normally not identify with (e.g., taking on a manager role), facilitating adaptive action. The necessity of varied action possibilities for adaptive action to occur may be leveraged when designing games by creating an open narrative that both contains diverse tasks to accomplish and encourages role taking.

Third, we found two interrelated experiences of shared action especially illuminating regarding how play sustains and furthers emerging collaboration – overcoming novel challenges and developing collaborative strategies. This may improve understanding of how between-group collaborative differences emerge during play in two related ways. For one, early disagreement can be detrimental to collaboration [49]. As such, failure to overcome early challenges, where interaction devolves into conflict, may hinder communication and collaboration emergence. Reversely, jointly discovering how to approach the game and overcoming the challenges posed may strengthen collaboration cf. [39]. Second, overcoming initial challenges together seems to make possible diverging trajectories of further collaboration emergence. This became apparent when groups created strategies for problem-solving and progression, which is necessary when participants are interdependent [50]. By building on emerging acquaintance and collaboration, successful groups created strategies seemingly fitting everyone's preferences. This can be interpreted as a form of *process coordination* – i.e., activities conducted to orchestrate processing of knowledge and resources [51] – which is contingent on established practice whilst simultaneously ensuring collaboration continues to emerge. These findings add to existing research on between-group variation [6], [40] by expounding how collaboration emerges and is sustained following trajectories shaped by individual and shared action. As such, challenges to overcome early on should be incorporated in game design to drive the emergence of collaboration – whilst ensuring the challenges are not too complex for a freshly formed team. Facilitators may aid this process by rapidly intervening and providing extensive support to groups that struggle, or experience conflict.

Based on the above, we argue that the shared actions described here emerge from play and should thus be interpreted as game-specific ways in which collaboration emerges. Supporting this notion, a key strength of collaborative serious games is that play reproduces social life, a vital part of which is for unwritten behavior and interaction rules (collaborative strategies) to emerge [21]. Expanding this, we argue that shared action experiences in play facilitates the production of interaction rules, enabling the emergence of collaboration cf. [8]. Additionally, we argue that overcoming challenges and forming collaborative strategies are experiences that facilitate collaboration by strengthening interpersonal understanding and feeling like a team cf. [1], if managed properly.

Fourth, this study demonstrates overarching differences between emergence of collaboration in games compared to non-game contexts through the situated experience games provide. To progress in the game, participants grapple with the lack of hard rules, wherein action depends on contextual factors. Participants cannot simply discover facts and apply them, they have to be creative, solve complex problems, and make decisions based on limited, malleable information – all whilst collaborating. This creates opportunities for novel and varied interactions, and new ways for collaboration to emerge. This was seen in how groups forged their collaborative *path*, i.e., how they interacted to progress through the game. Although paths taken differed greatly, a common dilemma was striking a balance between efficiency

(following prompts slavishly, goal-directedness, matter-of-factly interaction, etc.) and breadth (playing around, being creative, elaborating, taking detours, exploring possibilities, etc.). We believe these two ways of interacting are complimentary and both necessary for collaborative learning (and enjoyment). However, a narrow focus on the former diminishes development of procedural knowledge or know-how [52], whereas excessive breadth may incur fruitless discussion and halt progression. This balancing act can be understood in light of *constructive conflict*, i.e., managing diverging interpretations by arguments and clarifications [43], which is an essential part of collaboration [53]. Groups tending towards efficiency seemingly create less opportunities for discussion and argumentation, and thus less opportunity for constructive conflicts to arise. Furthermore, previous research on "gaming the game", i.e., striving to achieve goals optimal for winning but suboptimal for learning [54], seem closely related to efficiency-prioritizing paths. Our findings expand this, as we see wanting to win as only part of the reason why some groups did this – negative evaluation of discussion, creativity, and, ultimately, collaboration might also add to the issue. As such, it should be made clear to participants either through a facilitator briefing before play, or as a game element, that discussion and conflict should not be avoided but encouraged – to some extent. Facilitators may also strive to spot different paths and guide groups towards a productive balance. After concluding play, reflecting on discussion and conflict in the group may be an important step in debriefing.

In summary, we find that even over the short span of a single play session, serious game collaboration can be a complex, emergent phenomenon. Collaboration is in constant development during play, making it crucial to understand the processes characterizing how it unfolds. Furthermore, the emergence of collaboration seems to be different during play than in non-game context, and likely may develop more quickly and consistently in the game setting. Serious games seem to be able to create an arena for situated experience supporting novel forms of interaction, with a broad range of action possibilities fit for diverse participation, where groups co-create their unwritten rules of behavior and interaction to become a collaborative team.

4.1 Limitations and Suggestions for Future Research

The current study explores qualitatively how the emergence of collaboration exhibits high contextual variance due to e.g., participants, relationships, game (including content, mechanics, and task characteristics), setting. As such, it was not a goal nor a possibility for findings to have unmediated generalizability to different contexts. However, our findings should still be relevant and transferable to other, similar contexts cf. [55], acting as a steppingstone for further research.

First, the mindset of seeing difference as strength and taking action to benefit from knowledge diversity seems to support the emergence of collaboration. However, this interpretation is colored by knowledge and experience heterogeneity (diverging educational backgrounds and varying levels of experience) and contextual homogeneity (students attending the same course, living in the same city, roughly similar age) in the participant group. Future research could elaborate these findings by investigating the topic under different conditions, varying participant knowledge and experience (e.g., less educated players, older players with more diverse lived experience, specialists with in-depth knowledge) and/or different contexts (e.g., use in workplace training, cross-cultural applications, massively multiplayer games, public governance settings). Moreover, investigating the connection between mindsets and diversity impacting emerging collaboration and personality traits impacting team performance (cf. [40], [56]) may also be beneficial. One salient way to achieve this could be assessing mindsets and personality traits before play to better understand how these shape interaction during play, as well as outcomes thereof.

Second, by investigating collaboration emergence exploratorily we deliberately avoided pursuing specific emergent states – opting instead to discuss findings in light of them. Thus, our contribution to research on emergent states is limited, and divided across several possibilities. Further research should investigate specific emergent states using cognitive maps or other group-minded research approaches to provide insight into how emergent states emerge in the game context. Echoing the advice of Fyhn et al. [26] in another field, however, we urge researchers to take the emergent in emergent states seriously, by considering how both collaboration and emergent states emerge initially and develop over time.

Third, in our consideration of how games create a unique setting for collaboration we discovered that coming together to solve a novel challenge, with few set rules of interaction and problem-solving, might set games apart from other forms of learning. This should be considered both in the application of existing non-game collaboration research in future game research, and when further exploring ways in which games impact the emergence of collaboration. A caveat to this, however, is that the current study was conducted in a university setting – participants in other contexts could potentially be more well-versed with this form of interaction. Moreover, while this study explored how collaboration emerges, i.e., the conditions for collaboration, it would also be valuable to further investigate the cases where collaboration fails to emerge – as was the case for some groups in this study. Can this be attributed to inadequate communication or incommensurable personalities – or are there ways in which play and facilitation may have a mediating role? One way of investigating this which may prove insightful is to record (audio or video) groups during play and analyze their interaction, aiming to figure out what is missing compared to groups in which collaboration does emerge.

Fourth, practical implications for game design are included in the discussion of findings above, yet further research is needed to determine how these are best implemented, and which concrete game mechanisms may support this. Finding ways to utilize game mechanisms to support the management of individual differences, and individual and shared action, would likely be fruitful for making play less dependent on team composition, thus reducing between-group performance variation.

5. Conclusions

In this study we investigated how collaboration emerges during serious game play exploratorily, providing insight into how participants experienced playing and learning collaboratively. We found that how individual differences are handled, how participants act and interact to give each other a place in the group process, and the openness and novelty of play itself may contribute to the emergence of collaboration. The current study adds to the research literature in two concrete ways. First, this study expands understanding of how collaboration may emerge, complementing existing knowledge on how other phenomena impact collaboration, and vice versa. Second, the study provides insight into how games impact collaboration emergence, complementing research on how collaboration occurs and plays out in games. We draw attention to specific forms of interaction, made possible by play, strengthening collaborative emergence. This is just one part of how collaboration emerges – there are likely also other ways in which collaboration comes to be which participants did not, or could not, explicate. Additionally, other games, players, and contexts likely generate other forms of collaborative emergence. To truly understand how, when, and why collaboration benefits serious game learning, further research is needed to improve understanding of how collaboration emerges. Achieving this, we argue, will require a shift towards interviews & observation, audio & video recordings, and longitudinal measurements of collaboration-antecedental phenomena.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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