Completeness and collaboration in early design phase of learning games: Do ideation cards provide scaffolding?

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Abstract

Game-based learning (GBL) has proliferated rapidly in recent years, with both industry and academic research communities calling for collaborative work practices in the educational game design process that need to address all the key GBL aspects and create a shared understanding among team members. Design cards have the potential to improve idea generation and communication between stakeholders. However, potential scaffolding for completeness (focusing on all key GBL dimensions) and collaboration (working together to produce something) in learning game design is not explored. Therefore, in this paper we investigate how this design approach can scaffold for collaboration and completeness in the early phase of learning game design process using a card based GBL ideation toolkit in design workshops. Seven teams were analyzed using design artifacts and video recording of the workshop session. The results are encouraging in terms of the applicability of ideation cards in the GBL design process to scaffold completeness and collaboration.

1 INTRODUCTION

Game-based learning (GBL) is a multidimensional phenomenon depending on several aspects (e.g. users, learning, game factors, usability, environment, and affective reactions) for it to be effective [1, 2]. There is no single way to design a learning game, and not many specific methods scaffold for incorporating all the key

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elements of an educational game considering the involvement of different experts in its development, which makes it a different task [1, 3]. Researchers have pointed out that complex design products need to be understood from multiple aspects [4]. Therefore, an important requirement for the design process of a learning game is to focus on all the key dimensions of GBL [5], we refer to this as "completeness" in GBL design. Additionally, there is a need to achieve an adequate balance between these key elements (i.e., different aspects such as learning factors, game factors, technical factors, and user experience related factors) in the learning game to keep learning integral but still providing an enjoyable user experience for learner engagement [5, 6]. The design process of learning games is complex involving several professionals from different domains working together for a common end product [7]. Therefore, team collaboration is a critical factor in determining and maintaining the effectiveness in design [8]. Researchers have highlighted that team members (i.e., experts in particular domains e.g., designers and educators) often face difficulties in sharing knowledge in multidisciplinary setting. Each of them has a different area of expertise, ways to communicate, operating procedures, and use different approaches for idea representation [4]. Therefore, communication between them is not very simple to manage [1]. Researchers argue that it is important for a design team to communicate and negotiate with each other to make decisions by entering compromises [9]. Industry and research communities both require collaborative work practices in the design process [9]. "Collaboration" stresses knowledge co-creation through a common design process and peer collaboration stimulates cognitive engagement and motivation [10].

Researchers have already used design games as a means for understanding design as a social activity or for staging collaborative design effort involving many stakeholders [9]. Playful tools and design games have been used to structure the design dialogues between stakeholders and are suggested as ways to support and enhance collaborative ideation and concept design. The focus on play downplays the power relations and factors hindering idea generation [11]. Some researchers have used ideation cards for designing exertion games [12] and tangible games [13] and found them effective for idea generation, improvement and articulation, offering guidance, expanding participants' horizon, focusing the aim, formative evaluation and providing common vocabulary. However, how completeness and collaborative process for GBL design is facilitated through ideation cards is not explored.

According to [14] use of novel methods in early design phase can help adopt a wider perspective and Lucero et al.[15] advocate that general characteristics of design cards make them an effective tool for collaborative design practice. In this paper, we hypothesize card-based tool as scaffolding for collaboration and completeness in the ideation process of learning game design. We chose to focus on these elements for two reasons. Firstly, considering the nature of learning game design, these are vital for GBL design practice. Secondly, they can also be used as means for learning about the GBL design process as a collaborative design activity engaging various stakeholders. Our research objective is to investigate ideation cards as scaffolding for completeness and collaboration in early phase of learning game design process. For this purpose, LEAGUE ideation toolkit (see section 2.4) was used as the intervention in this study. We achieve our objective by focusing on the following two research questions: RQ1) Does the card-based toolkit support teams to address all key dimensions of GBL when ideating learning game design? RQ2) Which factors contribute to collaboration among team members when using card-based tool to ideate learning game design? In our analysis, we describe how collaboration and completeness is facilitated by using the card-based tool in the ideation process of learning game design. The contribution of the paper is twofold. It demonstrates the general usefulness of ideation cards

in the GBL ideation process (specifically in terms of completeness, and collaboration), and reflects on factors and design decisions in the employed card deck / activities that advance the key outcomes: completeness and collaboration.

2 RELATED WORK

This section summarizes some research studies that have explored or demonstrated the importance of collaboration and completeness in the design process of game-based learning or presented new approaches to design. We specifically highlight the research contributions in different areas incorporating the use of card-based methods in the design process and underline the efforts made in the game-based learning domain to acknowledge areas where future research may take shape.

2.1 Collaboration and Completeness in the Design Process

Several researchers focus on "completeness" in GBL design, i.e., addressing all the key elements of a learning game in the design process [1, 5, 16]. To facilitate this, De Lope et al. proposed a five-stage methodology suitable for designing learning games in which story plays a key role [5]. The study focused on the design phase, which structures the game with five key elements and proposes modeling tasks resulting in design artifacts such as diagrams or descriptive documents that can facilitate communication between design team members. Similarly, Silva [1] also presented a methodology divided into steps to support the design process of educational games to be more all-encompassing. It identifies the steps required to define the learning mechanisms in an educational game starting from the topic choice and ending with the user experience. Another study by Kellner et al. [16] presented guidelines for the development of adventure learning games (based on existing guidelines and frameworks) that help to evoke the inclusion of all key aspects in the design. However, these studies are limited in scope, focusing on specific game types or lack thorough validation for providing evidence to support for completeness in the design process based on generated game designs. Flexibility and ability to work in a broader perspective are recognized as key skills required for the 4th generation industrial revolution and should also be addressed in the field of educational game design [17]. Collaborative design emphasizes that all people are creative, and if provided with appropriate tools and settings, can effectively contribute to the design [18]. Da Costa et al. [19] described a co-design process based on a user-centered design approach in defining the concepts of a civic educational game. They relied on including the institution and users in the initial phase of the design process to provide an effective learning game. However, the results are limited in scope and showed that experience with only 4 or 5 children was productive. Tran and Biddle [7] presented an ethnographic study focusing on the day-to-day collaboration of the studio team for development practices in a small company working in the domain of serious game development. Their finding emphasizes that social and technical factors influence collaboration in the development process of serious games. They found that co-location and positive social environment facilitates the participation of different professionals in game development. The study reports on collaboration occurring within the game development team (consisting of six members) in a real context and not using any method or tool for scaffolding the team collaboration efforts. The team members had experience from working together for at least six months to two years, which might have influenced collaboration. Marne et al. [20] aimed to create a language with a design pattern library based on their six facet approach that should enable the team of designers and teachers to brainstorm and communicate their ideas and work together for holistic coherence. The results of this study are limited in scope

to indicate support for collaboration, as initial results were with single designers (either teachers or game designer working alone). Some researchers [18] followed an event-driven design process for codesign, where collaboration with team members is enabled through co-design events consisting of a predesigned structure, tasks, and facilitation resulting in a co-constructed understanding about potential designs, experiences, and context.

2.2 Use of innovative approaches to Aid the Design Process

Hannula and Irrmann [11] studied a design game for the planning of a service co-design project using video recording of interaction between an inter-organizational group of participants playing the game. The case selected for the study consisted of six players. Four out of six were from the platform provider organization, while two other players had no prior experience of the case before. The results highlight the ability of design games to scaffold for co-creation and interaction in the early phase of service co-design projects. Kayali et al. [21] used a mixed-method approach to develop informatics and society learning games with collaboration of high school students, university students, and researchers. They employed playing research and game analysis (which require students to learn about games through playing them reflectively) to prepare students for learning game design tasks where they use explorative design and design thinking methods to create the game. The research advocates the possible success of playful participation (without explicitly stating the encouraging aspects) for GBL design, but complete results are not presented, and the project was still at the early stage. Schmoelz [22] investigated playful activities in the classroom for enabling co-creativity. The design of classroom activity involved students playing the C2L storytelling card game called 4Scribes to explore different ways to deal with problems and find solutions. He used qualitative data collection methods for analysis, which included narrative-Socratic dialogues, gameplay videography, and field notes. The results support the use of playful classroom activities to facilitate co-creative reframing, co-creating a shared story, expressing emotions, and engaging in dialogue.

2.3 Use of card-based tools in various domains

Card-based tools have been used in various domains to facilitate user participation and creativity [23]. According to [24], the process most supported by creativity support tools is ideation or idea generation. Roy and Warren [23] analyzed 155 card-based tools with most aiming to aid human-centered design, creative thinking, or domain specific-methods. According to the review, some scientific trails indicated the usefulness of these tools to help designers generate innovative ideas, and feedback showed that cards could provide relevant information in handy form and support the design process. However, more testing and independent trials are required to confirm their effectiveness. Bekker et al. [25] presented a card-based design tool that describes the five perspectives on play. Only two of the five lenses were evaluated which showed promising results such as applicability for a variety of users, the cards proved inspirational for the design process (such as brainstorming and other design activities) and useful in analyzing the initial concepts, structuring information, and reflecting on design decisions. Similarly, Chasanidou [26] also presented a design tool named DEMO to design for motivation and found the use of artifacts such as cards and the structured processes as productive practices for the early phase of the design stage. Sintoris et al. [27] used a card-based gamification approach in two engineering courses to teach ideation and examined the produced design ideas and students' opinions regarding the tool and the design process. The students showed a positive response. However, there was a

contradiction between students' response and results of the workshops, as not many innovative ideas were produced, and there were issues with the feasibility of some cards.

Pernin et al. [28] employed the tangible version of the ScenLRPG method (built on visual formalism) based on a board game to design GBL systems specific for vocational training context. They investigated the use of game mechanisms to promote GBL designers' creativity and cooperation and effectiveness of board game-based design tool. Some researchers such as Mueller et al. [12] and Deng et al. [13] used card-based tools for supporting the design process of creating exertion games and tangible learning games respectively and got positive results from participants' survey. However, they do not focus on investigating the support these tools provides for completeness and collaboration in the design process from the generated game ideas and team interactions.

From the previous work, we find evidence for the importance of completeness and collaboration in the design process of learning games and the use of card-based tools to aid the design process by supporting initial idea generation, structuring information, reflecting on design decisions, offering guidance, introducing different perspectives, help in focus shift and evaluation. However, not much work is done to explore the use of a card-based approach to scaffold for collaboration, and completeness particularly in the GBL design process and investigating the contributing factors. Most of the existing card-based design tools were specific for a game genre or type, e.g. [12, 13, 28] and therefore could not be used for our study as they did not incorporate the key GBL concepts which are essential to investigate support for completeness. However, a particular approach with focus on GBL design is the LEAGUE ideation toolkit that have been used in this study. Motivation for using this card-based tool has been the special focus of the toolkit on key GBL concepts.

2.4 LEAGUE ideation Toolkit

The LEAGUE toolkit containing four card decks, a board with a playbook, five design activities, and a log sheet (shown in Figure 1) is used for ideation of learning game design in a workshop format.
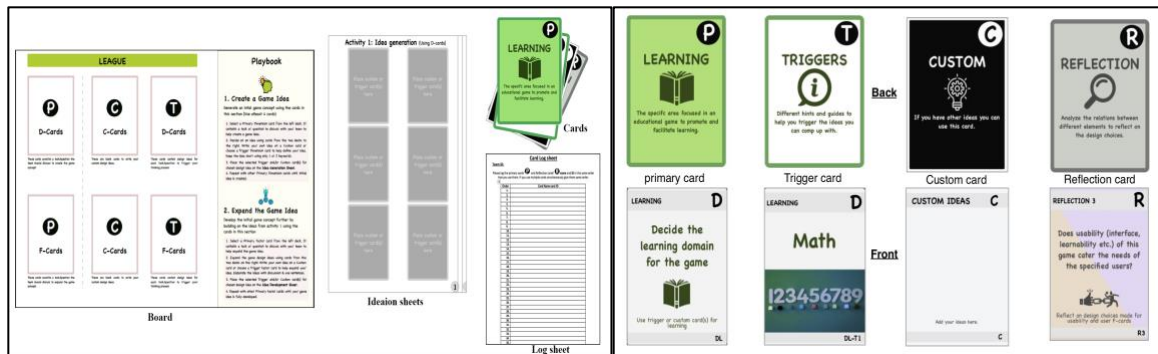

Figure 1: The LEAGUE toolkit Items (on the left) and four card types (on the right)

It contained the following different cards: *Primary* (28 cards), presenting 28 GBL design concepts in the form of a question or task, *Trigger* (113 cards), providing hints and example ideas for GBL design concepts, *Custom* (28 cards), blank cards to come up with own design ideas or custom solutions and lastly, seven *Reflection cards* providing critical lenses or evaluation criteria to reflect on generated design ideas and further refine them. The

playbook of LEAGUE toolkit introduces five design activities for ideating learning game design in a team of four to six participants using cards, ideation sheet and a log sheet. Each design activity has a separate ideation sheet that is used to produce the required design outcome of that activity. The design activities are played in sequence and are as follows: 1) *Idea generation*: coming up with an initial concept of a learning game using provided primary, trigger and custom cards. 2) *Idea development*: expanding the initial idea from the first activity and developing it further into more detailed and concrete one using provided primary, trigger and custom cards. 3) *Idea refinement*: improving or refining the developed ideas by reflecting on the design choices and identifying the limitations and questionable decisions using the reflection cards to think about the trade-offs between different GBL aspects that can negatively affect the design of the learning game. 4) *Idea illustration*: planning the overall flow of the game (illustrating how a user will play the game from start to exit) using flow diagram, screen prototypes or user scenarios. 5) *Idea documentation*: recording the final state of learning game design idea by producing a short version of a game design document (a format is provided to fill in the details of the final idea).

Primary cards are the main deck of cards presenting 28 GBL concepts (the building block of learning game design) that are successively selected by the playing team through collaborative discussion to ideate their learning game design. These 28 cards are groups in six categories (using color coding) emphasizing the six key GBL dimensions that need to be considered in any learning game design: learning factors, game factors, affective reactions, usability, user and environment. Therefore, these cards are useful for investigating scaffolding for completeness (achieving multidimensional focus) in the ideation phase of learning game design.

3 USER STUDY

We conducted three design workshops using the LEAGUE ideation toolkit as the intervention to investigate card-based ideation tool as scaffolding for completeness and collaboration in the ideation phase of the learning game design process. We used a combination of methods including observation, produced design artifacts and video recording.

3.1 Workshop participants and procedure

The workshops were organized in three different contexts: as a research study, in a doctoral summer school and a graduate course "Game development". In total, 34 people (ages 25-40) including, 16 master students and 18 researchers (Ph.D./postdoc), participated in the workshops that formed seven teams (each with 4 to 6 members). Two teams with 4 participants each, four teams with 5 participants each, and one team with 6 participants. There were 13 females and 21 males. The primary subject of study was computer science for all participants except two researchers from electrical engineering. Most of the participants (24 out of 34) had no background in learning game design, 3 had little experience, and 7 had moderate experience. The participants with no to moderate experience were selected to fully explore the support for completeness provided by the card-based toolkit and not influenced by their experience and knowledge ensuring the validity of data. The participants were selected through opportunity sampling and none of the participants had previously used the LEAGUE toolkit. The participants were explained the research objective of the study, asked to sign a consent form and were informed that their participation is voluntary.

The duration of GBL design workshops was approximately two hours and they were facilitated by two organizers. At the beginning of the workshop, participants were introduced (in 10 minutes) to the LEAGUE

ideation toolkit and key concepts of GBL. Subsequently, participants in teams are then asked to start the ideation session for learning game design with five design activities. Each design activity is first individually presented by one of the organizers, followed by the teams working on that activity. One team member acts as a logger and records the sequence of primary and reflection cards used by the team in a log sheet during the first three activities. All activities were time-bound and were organized as follows: the first design activity (idea generation) was of 10 minutes duration, in which teams had six primary cards to solve using trigger or custom cards, after that all teams summarized their initial ideas in a minute. The second activity (idea development) was of 30 minutes in which teams had 22 primary cards to solve using trigger or custom cards, followed by teams presenting their developed ideas in a minute. The third design activity (idea refinement) was also of 10 minutes in which teams had seven reflection cards to refine their ideas, and each team in a minute reported the refinements they made in their design idea. The fourth (idea illustration) and fifth activity (idea documentation) was run in parallel (20 minutes duration in total). Finally, after completing all design activities there were group presentations in which each team summarized the idea of their learning game design. At the end of the workshop session, the feedback was collected from participants through focus groups. The ideation and log sheets of teams were collected, and the play sessions of teams were also video recorded. Figure 2 presents one of the teams using the toolkit during the workshop and their ideation sheets and log sheet.
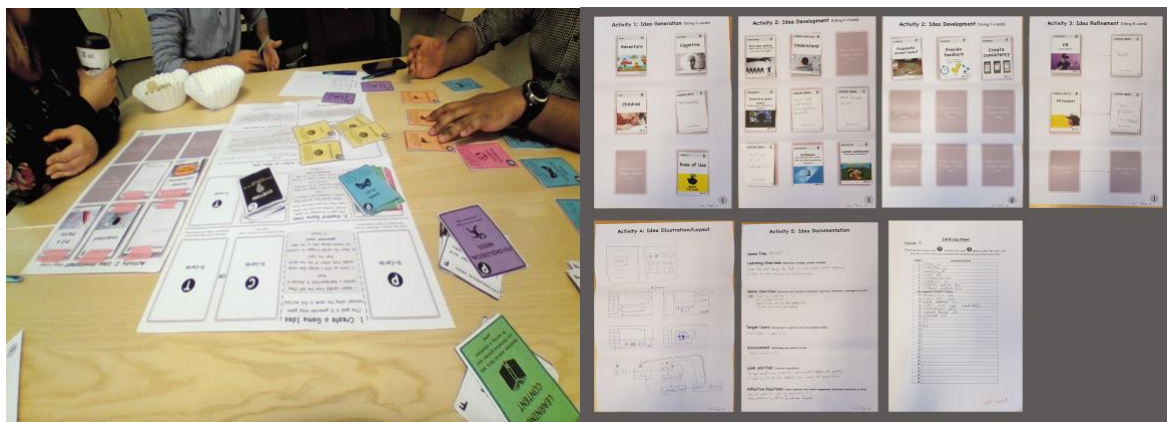

Figure 2: Image from the GBL design workshop (left side) and ideation sheets and log sheet of a team (right side)

3.2 Data Collection and Analysis

The previous work showed that the subjective opinion of participants is not enough to evaluate design cards [30]. Therefore, for this study, we used the toolkit artifacts (ideation sheets and log sheet, see figure 2) along with video recording to investigate the ideation process. The study focused on two main aspects: *completeness* and *collaboration* in the ideation process.

The LEAGUE toolkit presented a total of 28 GBL concepts using 28 primary cards that are grouped in six categories which are the six key dimensions of GBL that must be considered in a learning game design. These six key GBL dimensions are: Learning, Environment, Reaction, Game, Usability, and User. There are 5 cards for Learning, 3 cards of Environment, 5 cards of Reaction, 7 cards for Game, 4 cards for Usability and, 4 cards for User.

Completeness (focus on all the key dimensions of GBL to ideate learning game design): means that a team must focus on and incorporate at least one or more elements for each of the six GBL dimensions (categories) in their learning game design during the ideation process. For this study, the "completeness" is examined by investigated the inclusion of six key GBL dimensions (learning, game, reaction, usability, user, and environment) in the learning game design ideas produced by the teams. Although, it is not important to use all the 28 GBL concepts for ideating a learning game (to achieve completeness) as different concepts might be more or less relevant for different types of learning games, this thinking is in line with [29]. Nonetheless, it is crucial to cater all high-level dimensions (looking at the game from multiple angles achieving multidimensional focus) in every learning game design for it to be effective by focusing on the factors/concepts deemed important for that specific game.

The toolkit artifacts were used as a method for capturing the design decisions of teams in order to investigate "completeness" in their learning game design ideas. The log sheet detail the order of primary cards (GBL concepts) used by the team in their ideation process. The ideation sheets of each team provide insights to the key GBL dimensions covered in each activity. We used descriptive statistics to analyze the data for completeness.

Collaboration: is explored by the instances of interaction, discussion, and communication between team members facilitated by the card-based tool. The video recording of the play sessions (using a single fixed-point video camera next to the table, as shown in Figure 3) provided the data for team dynamics during the ideation process of the learning game design. Here, we were interest to investigate the ability of the card-based toolkit to scaffold collaboration. For this, we used video-based micro ethnography [15], a qualitative research method to gather information and understand how collaboration was occurring in the teams using the toolkit and what were the main contributing factors that initiated it. Many researchers have applied ethnography to study speech and moment-to-moment gestures in contexts such as workplaces, virtual environments, or classrooms [30, 31]. Our analysis focused on investigating the design dialogues between team members in ideation of learning game design throughout the video data. One case (team) was selected for video analysis in the context of this study in order to focus on detailed analysis and moment to moment interaction. The selection was based on random sampling. We used video analysis software V-Note Pro for analyzing the data for collaboration. The complete video recording for the selected case was 1 hour and 44 minutes in length. The video included the ideation session consisting of design activities, debriefing, and the focus group after the closing of the workshop activity. The video analysis was guided by the process presented by Heath et al. [32]. The analysis consisted of three rounds: in the first round we watched the whole video and created a content log, in the second round we identified the events of interest in the data corpus, and in the third round of analysis we selected the segments for detailed speech act level analysis. We selected five segments related to the five events of design activities for detailed analysis because these segments were most active concerning collaboration and relevant to illustrate how the tool affected the collaborative design process of team members. Next, a grounded theory approach by Gioia etal. [33] is followed to model, analyse and interpret the qualitative data collected through video analysis and present as a data structure. We coded the events and actions using the V-Note Pro tool. Events are the episodes in the video recording referring to different activities. The selected segments were coded using data-driven categories that resulted in actions. The actions are the collaborative acts (instances of collaboration) undertaken by the players within the activities. The result of the analysis is presented in the next section.

4 RESULTS

This section presents the results from the design workshops regarding the effectiveness of the card-based ideation tool to scaffold for completeness and collaboration in the early design phase of learning game. The LEAGUE ideation toolkit was used as the intervention in this study to analyze the scaffolding providing by the ideation cards. The results are compiled from the ideation session of seven teams using the toolkit through five design activities for ideating the educational game design.

4.1 Research Question 1: Completeness (GBL Dimensions Covered)

This section reports the use of primary cards and key GBL aspects covered by each team in different design activities and overall in produced game ideas. The used primary cards detail the GBL concepts focused by each team.

4.1.1 Most to least used GBL concepts. Figure 3 shows the classification of primary cards concerning team usage. The figure highlights three categories: most used cards (that were used by more than 70% of teams), moderately used cards (used by nearly half of the teams), and less used cards (used by less than 30% of teams).
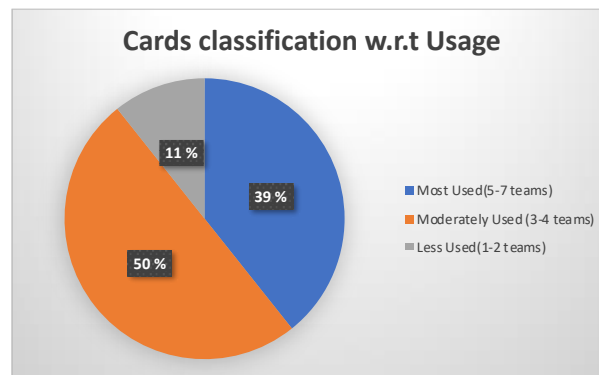

Figure 3: Classification of primary cards (GBL concepts) according to team usage

The results from Table 1 show that learning domain, game genre, user and learning objectives are the GBL aspects that were addressed by all seven teams, i.e., 100% usage; following these were the aspects such as environment, reaction, usability, gameplay, motivation, learner profile and technical aspect that were considered by more than 60% of teams. An interesting point is that in total, all primary cards were used at least by one team, indicating that all GBL concepts were useful for ideation. However, also not even a single team used all primary cards. This does not necessarily mean that all GBL concepts are not required but more possibly that different aspects are more important for different types of games. Also, the time restrictions explains why not all cards were used. The least important aspects, according to usage, were satisfaction, cognitive needs, and psychological needs, which were used by only 1 or 2 teams. This is also evident from the nature of these aspects as they require much deeper focus and analysis, which is not possible within 30 minutes duration.

Table 1: Team usage for individual GBL concepts

Primary Cards (GBL concepts)	No of Teams	Team Usage (%)
Learning domain-DL	7	100%

Primary Cards (GBL concepts)	No of Teams	Team Usage (%)
Game genre-DG	7	100%
Reaction-DA	5	71%
Usability-DU	5	71%
User-DÊ	7	100%
Environment-DE	6	86%
Learning Objectives-FL1	7	100%
Learning Strategies-FL2	4	57%
Learning Content-FL3	3	43%
Learning Outcome-FL4	4	57%
Game Definition -FG1	4	57%
Game Narrative -FG2	4	57%
Game Mechanics-FG3	4	57%
Game Resources-FG4	4	57%
Game Aesthetics-FG5	4	57%
Game Play-FG6	5	71%
Enjoyment-FA1	3	43%
Engagement-FA2	3	43%
Motivation-FA3	5	71%
Flow-FA4	4	57%
Interface-FU1	4	57%
Learnability-FU2	3	43%
Satisfaction-FU3	2	29%
Learner Profile-FÊ1	5	71%
Cognitive Needs-FÊ2	2	29%
Psychological Needs-FÊ3	1	14%
Technical Aspects -FE1	5	71%
Context-FE2	4	57%

4.1.2 Total number of GBL concepts used. Figure 4 presents the percentage of primary cards used by each team. Primary cards are a total of 28 different GBL aspects, 6 in the first and 22 in the second activity. Four teams (57%) used all six primary cards in the first activity, meaning they focused on all six GBL aspects.
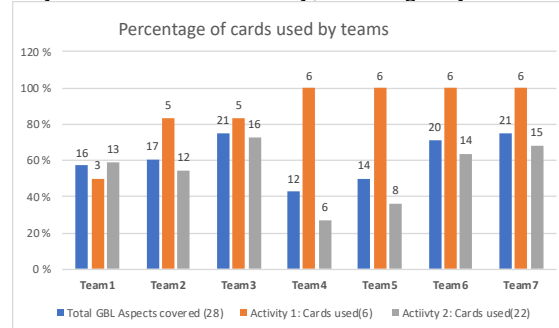

Figure 4: Percentage of primary cards used by teams

The minimum number of cards used in activity 1 to generate a learning game idea was three (out of six) cards used by team 1. However, this did not affect the overall "completeness" of this team, as shown in figures 5.

None of the teams used all 22 cards in the second activity, the maximum number of cards used were 16 by team 3 meaning they addressed 16 GBL aspects (out of 22) in the second activity, and the minimum number of cards were used by team 4 (only 6 cards). Similarly, the total cards used by the teams also vary, with team 3 and 7 used 21 cards (maximum) in total, and team 4 used only 12 cards (minimum) in total.

4.1.3 GBL dimensions covered. Figure 5 (left side) shows the percentage of key GBL aspects (out of six key categories) addressed by the teams in each design activity and overall produced game idea. It is interesting to note that all the teams addressed all six GBL aspects in their overall produced game idea, which shows that the used toolkit was effective in scaffolding for "completeness" in GBL design. However, when further analyzed in detail, not all six aspects are fully addressed by all the teams. Figure 5 (right side) illustrates the percentage of each category covered by the seven teams.
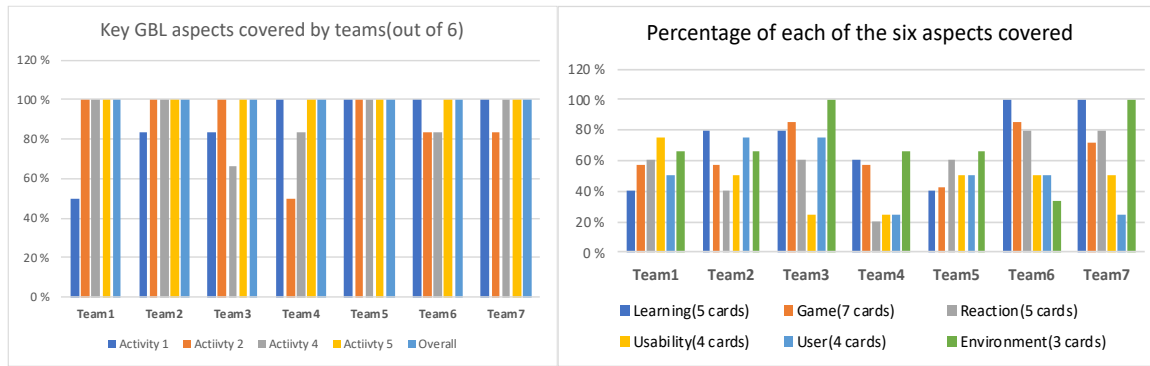

Figure 5: key GBL aspects covered in different design activities (left); each of the six GBL aspects covered (right)

We also investigated if there exists any typical pattern (in the order of use of primary cards) that most teams followed in developing learning game design ideas, which could be useful to guide the process to other novice GBL designers. As primary cards are different GBL aspects used for building learning game design, a successful pattern could guide the GBL community regarding the best practice to tackle multiple GBL aspects for efficiency and effectiveness in learning game design.

As the 28 primary cards are divided into the first two design activities: 6 primary cards are used in the first activity, and 22 primary cards are used in the second activity. Therefore, to identify any pattern, we calculated the mode of "order of use of each card" for the seven teams for activity 1 and 2. Figure 6 highlights the pattern in order of the use of primary cards in activity 1 and 2. The typical pattern identified in activity 1 "idea generation", as shown in Figure 6 (left). was: First the primary card "game" was used, then "learning", followed by the "environment" of the game. Further, the teams typically used a card that addressed the "reaction" that learning game intended to generate, followed by target "users", and lastly the "usability" aspect. For the second activity "idea development", the set of data values for only seven primary cards (out of 22) had a mode. The order of these cards is presented in Figure 6 (right), where the remaining cards had no mode value. One reason for this is the small sample size (only seven teams), and the percentage of usage for these cards was less; therefore, no frequent number was identified. Thus, we assume that it is possible to identify a clear pattern if the study is repeated with more teams (large sample size).
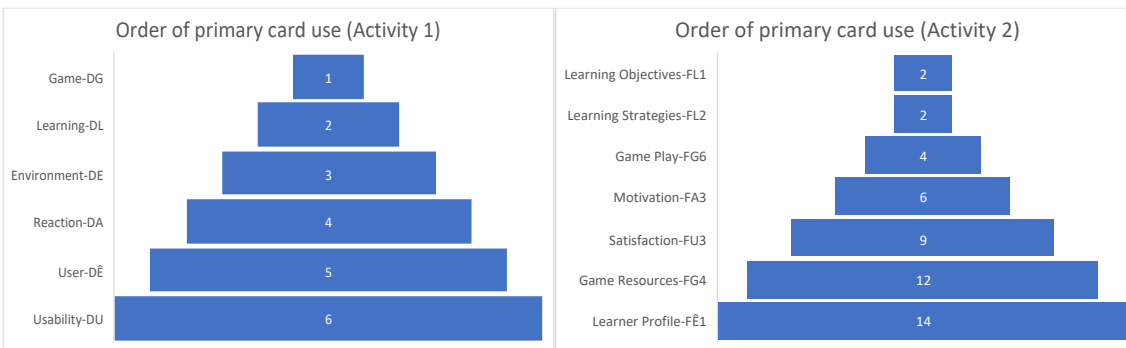
Figure 6: Order primary cards in design activity 1 (left); Order of use primary cards in design activity 2 (right)

From the identified order of use, we can see that "learning objectives" and "learning strategies" are mostly addressed at second number (out of 22). This also means that once you have addressed all the six key dimensions of learning game in the first activity in a specified order, most teams first focus on addressing the factors of the "learning" dimension followed by "gameplay". Therefore, the initial focus in second activity is also on factors related to "learning" and "game" the same as the first activity. After that, "motivation" is addressed mostly in sixth place, followed by "satisfaction" in ninth place. Finally, "game resources" and "learner profile" was mostly focused at number 12 and 14, respectively.

4.1.4 The produced learning game design ideas. The learning game designs ideated by the seven teams are presented below to exemplify the multidimensional focus in each produced idea.

Team 1 (XXXX runners!!!): All students at [XXXX] university with assignments learn to work as a team to achieve a common objective that is deadline extension by running away. The [XXXX] campus has sensors that are linked to GPS location used in the web game. The students work as a team and define strategies of mass escaping. The goal is not to be caught by the professors. The players use different avatars and different colors for professors and students. Each student team has to use the same color of t-shirt and cannot leave the NTNU campus. The environment changes depending on the difficulty level of the assignment using 3D-videos. If the team succeeds in escaping from the professor, they get deadline extension for that specific assignment, which gives them a sense of achievement and stress relief.

Team 2 (Math-ur-mind!): A puzzle-based mobile game for kids aged 8-12 years to understand math concepts through drill and practice using great graphics. The game can be played anywhere any time to develop math competencies and improve processing speed by solving interesting tasks in an interactive and fun way by providing immediate feedback on actions to give satisfaction.

Team 3 (Save the planet!): An outdoor tablet game for the elderly to change attitude and behavior regarding global warming and shopping behavior because they are not well informed about climate change. The game has vibration keys with easy navigation and audio features. Different interesting tasks (e.g., earn points by picking up the trash to clean the planet, shoot the plastic bags to free the planet, etc.) with constructive feedback allow the elderly to learn about recycling and mass production. The game provides fun facts on how to recycle and avoid global warming.

Team 4 (Swing or Die/ My swinging 20's (or Die): An augmented reality game for the elderly with mobility issues to learn how to dance. The players get to dance with their idol. They have to learn to dance correctly

according to the indicated move patterns shown by colored areas. The game uses an AR headset and motion tracking to indicate player to step in the right boxes at the right time to compete to dance with some famous idols. The game uses a 3D environment with old school aesthetics. Players can choose between different levels with various dancing patterns, locations, and dance types along with increasing difficulty. If the player loses the competition, they will die.

Team 5 (PROGBOT): A cross-platform game for school children grades 5-7 to learn programming and related concepts. The player guides the robot through the levels by using simple symbolic programming as the main mechanic. The game has different levels on a world map, and players complete each level to conquer the area and defeat the enemies. They can upgrade the robot with coins from completing levels. The player controls the robot by programming it. The game has a purposeful and consistent interface, and gameplay provides clear feedback when running the "program/solution" and induce confidence by allowing for small steps of growth.

Team 6 (Code and Conquer): A mobile game for children in primary school interested in technology to understand, apply and develop competencies in programming skills through drill and practice and scenarios. The goal is to eliminate all the opponents. The game uses animation and tutorials and provide feedback and hints to develop competencies.

Team 7 (Smart city simulator (SCS)): A 3D simulation VR game for young adults (15-30 years old) to understand smart cities. A player uses VR headset and VR controls to organize a smart city to increase knowledge of smart cities concepts and seek cognitive reaction. Players use drag and drop to build buildings using 3D visualization. The game goal is to increase the inhabitants' happiness levels by developing smart cities. Inhabitants' happiness gives enjoyment, meaningful purpose, and an immersive game world gives engagement.

4.2 Research Question 2: Collaboration (Main Contributing Factors)

We followed the grounded theory approach by Gioia etal. [33] in conducting and presenting the analysis. The analysis started with finding recurring actions where collaboration occurred, forming first-order concepts (denoted as actions) from the data. We recorded the occurrences of these actions in V-Note, each with starts/ends time. Hence, it was also possible to count the number of occurrences of each action during the design process, which makes it easier to investigate the frequency of different actions in events, in specific time intervals, or over the whole ideation session. The next step was to extract the themes guiding these actions of collaboration. Based on first level codes (actions), we start seeking similarities and differences in the codes and grouped them to generate second-order themes (theoretical concepts from the data) explaining how codes related to each other. The second-order themes represent the main factors contributing to collaboration among team member using card-based toolkit. Finally, the second-order themes were compared against each other to distill them into "aggregate dimensions" that explain how card-based toolkit scaffold collaboration in the early phase of GBL design process. The resulting data structure for collaboration among team members in ideating learning game using card-based toolkit is shown in Figure 7.
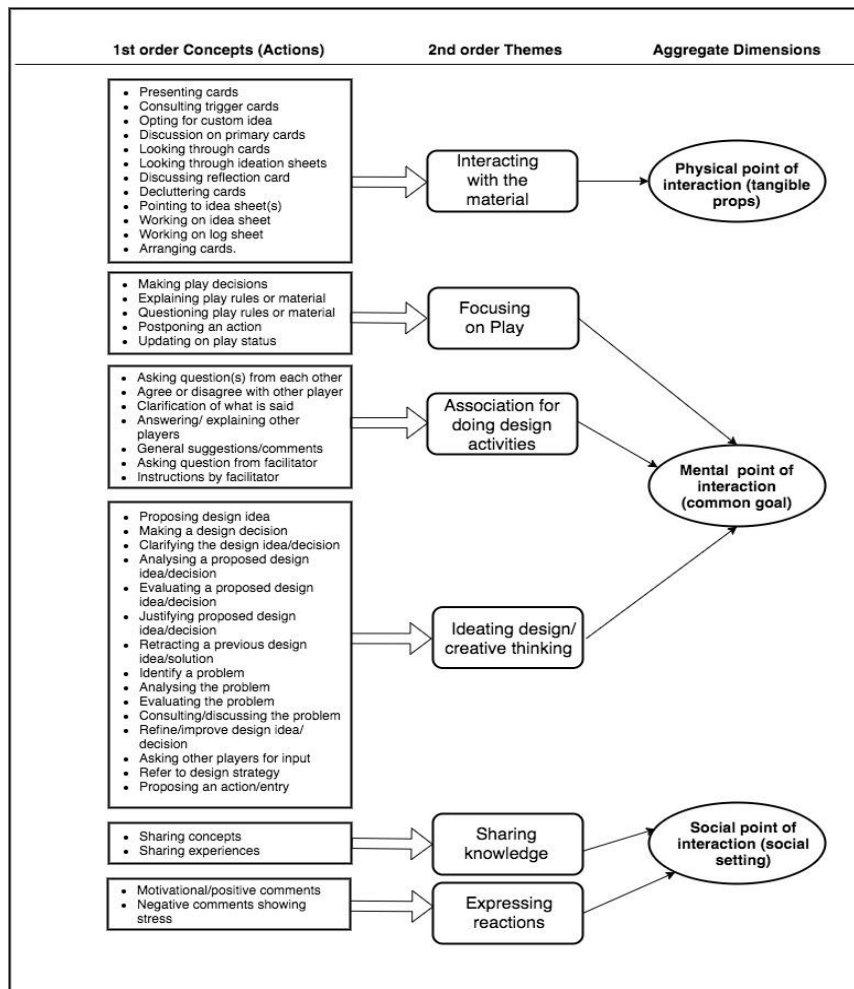
Figure 7: The data structure for collaboration in ideation process of learning game design facilitated by card-based toolkit

Our analysis resulted in the following six themes that characterize interaction in the GBL ideation process when using card-based tool:

- Interacting with the material: In this theme, the contributing factor was the toolkit material that mediated the player's interactions. These instances of collaboration revolve around actions such as presenting cards to other team members, discussing different cards, working on the ideation sheets, or pointing to previous idea sheets. Interactions also included players together arranging, decluttering, or looking through cards for either initiating a discussion or further elaborating on it.

- Focusing on Play: The acts of collaboration in this theme were focused on play-related interactions. The players were engaged in discussing the plan, making play decisions, e.g., which aspect to take first, postponing something for later, asking questions about play rules, or explaining play rules to other players. Team members would also update each other on the status of play, e.g., what has been already done and what is still left.

- Association for doing design activities: Here, the contributing factor for collaboration was the association that was needed for collectively performing the design activities. It consisted of players asking questions and giving answers to each other (e.g., Player1: Who wants to write?; Player 5: I can write); asking questions from the facilitator (e.g., Player 1: Do we build on the previous activity?); agree or disagree with other players (e.g., Player 3: You look like you like drawing!; Player 2: No no! who said.); clarifying their point in a discussion (e.g., Player 2: No, I mean this is something that is already available) or giving general suggestion or comments (e.g., Player 2: It's better to stick them on the sheets at the end; Player 4: Let's move on!). The facilitator also enabled these interactions by often giving some instructions or presenting new information or choices (e.g., you can use more sheets; you can look through other sheets for getting an overview) to the team.
- Ideating design/creative thinking: In this theme, all collaborative interactions were instigated by co-creating the design where the players proposed design ideas, made collective design decisions by asking other players for input or analyzing, clarifying, evaluating a design idea. Players developed their design strategy as a team, justified proposed design ideas and also identified problems, analyzed and evaluated them through discussions, or referred to previous design solutions in order to improve or refine the design.
- Sharing knowledge: The contributing factor that mediated interactions in this theme was sharing knowledge and information. Players referred to their past experiences related to topics under discussion or to generally build a rapport with others. Players also explained concepts to each other they knew could be useful in the process of creating shared understanding and awareness.
- Expressing reactions: These instances of collaborations were triggered by the feelings that players experienced within the playful and collaborative setup. The team members expressed their positive and negative thoughts and reactions at different points (sometimes within an activity and sometimes at the beginning or end) that indicated their motivation or stress.

The six themes aggregated to identify the three central features of card-based toolkit that scaffolds collaboration. A card-based toolkit provides three points of interaction that effectively instigate and foster collaboration among team members: Physical point of interaction, mental point of interaction, and social point of interaction. The physical point of interaction is created by tangible props that serve as director and structure the activity forming building block of play. The mental point of interaction is created by the common goals that serve as actors that lead to performing the stated activity, i.e., ideation of learning game design. The social point of interaction is formed by the social setting that serves as a supporter that encourages participation by providing a friendly environment.

These three points have mutually beneficial relationships that together support the collaborative design process. The tangible props provide a steppingstone and generate a physical point of interaction that supports both attaining the common goal (by posing questions and providing hints) and encouraging social interaction (by providing initial grounds for initiating interaction). The social setting provides a friendly environment making it easier to share knowledge and information that leads to improved ideation providing confidence for creative thinking. On the other hand, the common goal is the driver that motivates to make an effort to strengthen all types of collaborative interactions for achieving the objective.

5 DISCUSSION

The results are discussed concerning scaffolding provided by the card-based ideation tool for completeness and collaboration in GBL design process to address the two research questions.

From the analysis of generated ideas in different design activities and observation of workshop session, we have established that the employed card-based toolkit performed well in scaffolding for completeness by facilitating the teams to overall address the six key dimensions (categories) of GBL in the produced game design

ideas. However, not all elements were focused in each of the six GBL categories. One reason is the nature of a design workshop that was time-bound, which restricted the freedom to be able to complete all cards. In practical setup, this can be controlled by changing activity rules from time bound to finishing cards. All primary cards were used at least by one team, indicating that each and every card (GBL aspect) was relevant. However, some GBL aspects were more focused than the others. The learning domain, game genre, target users and learning objectives of the game are the GBL aspects that were addressed by all seven teams. Whereas, satisfaction, cognitive needs, and psychological needs were least focused by the teams, perhaps because these aspects require deeper focus and analysis and thus more time was required.

The physicality of individual card items makes them different form other approaches such as design model/framework or checklist by affording actions such as grabbing, pointing and sorting or grouping [13]. Team members focused on individual items deemed important for their learning game idea, area of expertise or previous experience to start a discussion or bookmark their ideas. The cards help participants in externalizing the design rationale making the ideas concrete and more accessible to themselves as well as other team members [13]. Also, as each card focused on one specific GBL element, it provided a comprehensive enough description of that element (using definition, examples or images) making it easier for all stakeholders (from different areas) to understand the concept or for team members to use that tangible information to further extend and explain their ideas to other team members. The different categories of primary cards supported achieving multi-dimensionality. Since cards act as tangible idea container, by converting the key dimensions into different card categories the question cards acted as design building blocks that team members used to develop and complete their design ideas from multiple angles (achieving multidimensionality in design). The format of the final activity required documenting all the key GBL dimensions which severed as a reminder for the team to revisit the design decisions and ideation sheets and improve their idea by working on the missing aspects. It restricted the teams to focus on all six GBL dimensions in the final activity. However, it is not the only feature that lead to completeness, almost all teams focused on the complete six GBL dimensions in at least one other design activity in addition to activity 5 (see Figure 5). Therefore, breaking the ideation task in different activities adds to supporting completeness as each new task put things into perspective, proving an opportunity to revisit the design decisions and further add or modify them if needed.

Our study also highlighted the potential of ideation cards to facilitate collaboration among team members in the early phase of the GBL design process. We identified three aggregate dimensions from six contributing factors that facilitate collaboration in the specific context of using a card-based toolkit. The toolkit scaffolds for collaboration by providing three points of interaction in the design process, namely: Physical point of interaction (tangible props); Social point of interaction (social setting), and Mental point of interaction (common goal/task). This type of card-based tool also has a strong potential of being a framework for analyzing the GBL ideation process of multidisciplinary teams.

5.1 Limitations of the Study

One of the limitations of this paper is that there was no control group to compare the results and assess the effect of intervention. We could use a control group employing some other approach (such as checklist or framework) but we wanted to demonstrate its effectiveness in designers practice where normally no such approach is used. We conducted design workshops for this study instead of using the toolkit in designer's day-to-day practice in a game studio with professionals as it was practically difficult to achieve. However, the

previous work [12] suggests that design workshops are a way to approximate design practice. As it offers similar environment with team-based design exercises and time-constrained format, similar to the environment to which designers are exposed. Another limitation of this study is that the LEAGUE toolkit is not representative of all GBL ideation cards. Therefore, the results are only generalizable to ideation cards presenting similiter features to LEGAUE or providing enough knowledge of GBL concepts. One could also argue that completeness was evaluated empirically using toolkit artefacts (counting number of GBL aspects covered by each team) whereas expert evaluation could provide useful insights on the quality of generated ideas. However, for the context of this paper we were merely interested in understanding the scaffolding provided by the toolkit for achieving multi-dimensional focus in generated ideas (considering the learning game idea from multiple angles) and not the quality or effectiveness of generated ideas (which off course is important but was not the main focus of this study). Lastly, the participants of the workshop had no to little experience, this was useful to explore the support for completeness provided by the card-based toolkit and not influenced by their experience and knowledge ensuring the validity of data. It allowed us to examine the use of the cards for early career but not for senior designers.

6 CONCLUSION

Collaboration and completeness (considering the game from multiple angles) are vital in GBL design process [5, 6] [7] [9] but are difficult to manage in practice [1, 3]. This paper attempts to solve this problem by postulating ideation cards as scaffolding for collaboration and completeness in the early design phase of learning game, advancing the state of the art. The paper investigates the ideation process of learning game when using a card-based ideation toolkit, focusing on contributing factors and design recommendations for improvements. The data collected from the design workshops highlighted the useful of card-based tool for scaffolding completeness and collaboration. All teams focused on the six key dimensions of GBL in ideating their learning game design using the toolkit. The toolkit features that most contributed to scaffold completeness were different card categories, and different tasks (design activities) in addition to the general characteristics of cards as tangible idea containers. The toolkit features that most contributed to collaboration were tangible props, common goals and social setting.

Future work will focus on identifying GBL design patterns in the ideation process that can result in effective and efficient learning game designs to further help GBL designers with the process of designing learning games. A larger sample size is needed for this purpose, and we intend to use the toolkit with professional GBL design teams consisting of multidisciplinary experts. Future work should also focus on considering other existing card-based tools for GBL ideation and design to act as ready-made scaffolds for completeness, and collaboration to validate the effectiveness of this approach in a GBL design process. We will also extend the study dimensions to include creative thinking, which is also essential for the early design phase of learning games.

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