

Introducing Pattern Cards for Mixed Reality Game Design

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ABSTRACT

This paper describes a set of playing cards creating a pattern language for designing Mixed Reality games. The deck of cards was used in a two-week workshop with users inexperienced in the field of Mixed Reality game design. The paper talks about the design process that led to the current version of the cards and presents positive initial findings resulting from the workshop regarding the applicability and usefulness of the cards.

Categories and Subject Descriptors

K.8 [Personal Computing]: Games.

General Terms

Documentation, Design, Experimentation, Human Factors.

Keywords

mixed reality, games, location-based games, pervasive games, design patterns, pattern language, pattern cards, playing cards, user study, game design

1. INTRODUCTION

Mixed Reality games combine digital elements with aspects from the real world. Enabling devices like smartphones and sensors as GPS or NFC enable new and exciting forms of play. Other names for these games include Location-based games, Pervasive games or Augmented Reality games. The development of these games is certainly difficult from a technical point of view, but also (or arguably even more so) from a conceptual point of view I regards to game design. Mixed Reality games create new opportunities for game design while at the same time also posing unique challenges. As attempt to collect existing knowledge about Mixed Reality game design a pattern language has been developed [26]. In order to support the creative process when brainstorming for new game ideas a set of physical playing cards has been developed that extend (and adapt) aforementioned pattern language. This paper describes these cards and how they have been used in the context of a two-week workshop with students inexperienced in the field of Mixed Reality games. The paper starts with a background overview of Mixed Reality games and design patterns in general. It then describes how the cards were developed and what considerations led to their current form. Next, the set-up of the workshop is laid out and the results are presented. Questionnaires handed out to the students build the basis for a discussion section. The paper closes with conclusions and a look at future work concerning the pattern cards.

2. BACKGROUND

2.1 Mixed Reality Games

The term Mixed Reality game includes a broad variety of games. They all have in common that they combine real world elements with digital content. One of the earliest examples for a Mixed Reality game is *GeoCaching* [15] where players use GPS sensors to find (real) treasures hidden in the environment. Augmented Reality games like *ARQuake* [22] or *Human Pacman* [9] equipped

the players with laptops and head-mounted displays to display virtual characters embedded into their field of vision. Alternate Reality games like *The Beast* [23] sent players on a (web) hunt for clues questioning what is part of the game and what is not. *Can You See Me Now?* [6] was played remotely with players virtually moving on a map interface while NPCs were running through the real city streets. Location often plays a very important role in these games, and it is frequently made a core element of game play like in *REXplorer* [5] where players follow a medieval narrative embedded into the history of Regensburg, Germany. Games might make use of GSM cells for positioning, GPS, fiducial markers, natural feature tracking, NFC/RFID or Wi-Fi and Bluetooth-based proximity sensing. If a game is closely coupled conceptually to a certain area, it is often difficult to stage it at another location altogether. Some games like *Tidy City* [24] allow players to become content creators themselves and create new missions for other players. Many of these games are event-based and require real-time orchestration by the game masters. Some games include live-action roleplaying elements like *Interference* [17], and others make it necessary to react to the general flow of the game and (unexpected) player actions [10].

Commercially available games do not yet make up a large percentage of the smartphone games market. Some of the most prominent examples include the likes of board game inspired *Mister X Mobile* [12], modern scavenger hunt *SCVNGR* [21], as well as the recently discontinued *Shadow Cities* [14] or Google's *Ingress* [20] (both of which let players join a global war for control of valuable locations).

2.2 Design Patterns

The concept of design patterns was first proposed in an architectural and city planning context [1] [2] and followed a problem-solution approach. The patterns described issues arising when developing towns and cities, planning neighborhoods, constructing a house or interior design. Each pattern consisted of the description of the problem as well as a thorough explanation of how to overcome it. Together, the collection of patterns formed something called a *pattern language*, aiming to provide an exhaustive overview of the design questions at hand. Since then the idea of design patterns has been adapted into a variety of other areas.

Design patterns for software engineering [13] provide hands-on solutions for typical programming challenges and offer generic and language agnostic solutions to these.

Game design patterns (with a strong focus on video games) have been proposed [18] and also quite intensively covered [7]. Unlike the aforementioned architecture and software patterns, this pattern language does not follow the problem-solution approach. Instead, it describes game mechanics, their uses, occurrences, consequences and connections in a more neutral and descriptive manner. Similarly, the Game Ontology Project (GOP) [27] strives to analyze and identify established game elements and mechanics without including judgment of how they should be applied best.

There are some sources for design patterns for mobile gaming in general [11], albeit not necessarily with a focus on Mixed Reality games. Further insight into design challenges and characteristics of Mixed Reality games can be found in work covering design guidelines [19] [25], which are not too dissimilar from design patterns.

3. DESIGN PATTERNS FOR MIXED REALITY GAMES

3.1 Initial Considerations

A first foray into the creation of a design pattern language for Mixed Reality games has been made before [26]. A set of 11 patterns had been derived from existing games covering several categories: game mechanics, content authoring, interfaces, development and run-time orchestration. The patterns followed the common problem-solution approach and had subsequently been stored in wiki format, similar to the Game Design Patterns 2.0 wiki [8].

After establishing this first version of the collection, a logical next step was to test the applicability and usability of the developed patterns in various previously proposed scenarios:

- *Communication* (discussion/collaboration)
- *Analysis* (representation/standardization)
- *Creativity* (outlining/planning)
- *Improvement* (problem solving/prevention).

When the opportunity arose to organize a workshop with students at the University of Lincoln, *Creativity* and *Communication* were chosen as interesting angles to explore in this setting. The students would have little to no previous knowledge about Mixed Reality games and would thus be required to “learn a new design language” for which the patterns might provide a suitable solution.

As mentioned above, the initial set of design patterns were structure in a wiki format. While such a presentation has many advantages (easy to add or edit content, interlinked patterns, practically unlimited space), it did not necessarily seem to be the best approach for such a workshop. The goal was to engage the students in active brainstorming discussions, building their games step-by-step and modifying them throughout the process. A wiki could on the one hand easily overwhelm them with the sheer amount of text to read and on the other require them to focus their attention on digital screens which arguably is not the best environment for fruitful discussions.

Promising related work was done with a set of playing cards for sound design patterns in videogames [3] [4]. Here, cards were developed to help users in brainstorming exercises based on these patterns. This approach seemed very suitable for the proposed structure of the workshop; therefore the decision was made to develop the patterns as a set of physical playing cards. In theory, such playing cards would enable a sharable experience and foster communication between the students. They could quickly move the cards around, pick them up and sort them however they like. Due to their limited physical space, the cards would also be quick to read while at the same time (hopefully) provide enough information and ideas to foster productive brainstorming sessions and serve as a good overview of the design space of Mixed Reality games.

3.2 Development Process

The 11 previously developed patterns were the first ones to be transformed into cards. Different card designs were developed

with different amounts and types of information as well as different physical sizes. The physicality of the cards made it necessary to restrict the amount of information on each card. Where the original patterns had no limitations in the depth of description, the card versions of them had to be streamlined and reduced to the essentials.

3.2.1 First Iteration

As a starting point the following attributes were chosen based on the existing pattern language: problem name, problem triggers, problem description, problem game examples, solution name, solution description, solution game examples, further solution considerations and relations to other patterns. In order to make the cards visually more appealing and distinguishable from each other, an image was chosen to illustrate each pattern. In addition, cards were given a solid background color (to be later designated for e.g. different categories)

The first two prototypes were developed in parallel. One dedicated one side to the solution and the other to the problem (Figure 1), while the other one created one side as a quick overview and the other one with more detailed information (Figure 2). Both versions were printed in two different sizes each: 15cm x 10cm and 11.5cm x 8cm respectively.



Figure 1. Prototype separating problem (left) and solution (right).



Figure 2. Prototype with basic information on the front (left) and more details on the back (right).

Several different cards in these four combinations were then shown to a small group of researchers that had previous experience with creating Mixed Reality games. At this stage the

actual content of the cards were not considered but instead solely the layout of the cards. Positive comments were given for including images, different background colors, the amount of information of the cards and using black and white to distinguish problem (black background) and solution (white background). The two main negative points were the fact that the different content boxes did not intuitively convey what kind of information they were about and the fact that the cards did not use common size dimensions and were too large in general. In regards to the different ways of organizing the content of the cards, a preference for the separation of problem and solution was expressed. The approach of having problem and solution on the same card was however questioned in general. From the experience of the feedback group, the creative process usually started with an interesting game idea (so one or several “solutions”). It was also mentioned that a 1:1 problem-solution mapping does not always work in a creative process (as there might be several solutions to a problem and vice versa) and thus a final suggestion was to split up problems and solutions from each other.

3.2.2 Second Iteration

The second iteration of the card design was driven by the suggestion from the feedback round to split up problem and solution. As an example one might think about “Too much running” as a problem often emerging in Mixed Reality games: Players are indirectly encouraged to quickly run around the game area as this grants them certain advantages over their competition (e.g. ability to score more points in the same time). While some games like *Mister X Mobile* might actively promote such behavior, others do not actively aim for this to happen but do not prevent it. If a game with a strong narrative focus turns into a race, its players might not appreciate this style of play. One common solution to this problem is the use of social contracts: Before the game players agree not to run (the effectiveness of such a promise is another question entirely). Another solution might be to implement a speed limit based on e.g. GPS data like done in *aMazing* [16].

The question now becomes: How to represent these two solutions with physical cards? One could place both on the back of the same card – but this would cut the space for each solution in half (and what if a problem has three or more solutions?). Another approach would be to create two cards: Both with the same problem description on the front but a different solution on the back. This, however, could quickly lead to confusion, as it makes distinguishing between those cards difficult.

Therefore problems and solutions were indeed split up physically and no longer represented on the same card. The next prototype saw one part of the deck of cards talking about problems of Mixed Reality games while the other part provided solutions for these problems. The drawback of not having a direct mapping anymore between the two was not seen as too much of an issue: It would require users to think of how to overcome certain problems and not immediately provide them with a default answer (and thus potentially stop their creative thinking process by opting for the default solution). It would also enable users to subvert problems and turn them into something positive or just look through the solutions for interesting game mechanics – without having first to think of a specific problem. In order to reflect this change, problems were renamed into *Challenges* and solutions became *Opportunities*.

A closer look at some of these *Challenges* and *Opportunities* revealed that not all of them fit perfectly into these two groups. Thinking back to the *Challenge* of “Too much running” it was

already stated that games like *Mister X Mobile* make the conscious decision to include a high amount of running as one of its main game mechanics. After all, the physical aspect is what sets many Mixed Reality games apart from their videogame counterparts. Therefore it did not seem fitting to phrase the running aspect of a game as a *Challenge*. It rather was a question the game designers had to answer for themselves while designing the game. How much running do they want? Depending on their decision they would then have to look for means to make the game behave in the desired way. With this in mind, other *Challenges* were inspected and some of them were equally better phrased as a question. This also made it possible to add other elements important for designing Mixed Reality games as cards like choosing a suitable sensor or defining where a game was played (e.g. inside or outside).

In the end it was decided to have three distinct groups of cards complementing each other: *Challenge Cards*, *Opportunity Cards* and *Question Cards*. Apart from the *Question Cards* the other two groups were further divided into sub-categories to make them easier to distinguish and make it obvious from a quick glance what kind of topic they dealt with. The final sets of categories were decided upon after creating a substantial amount of cards. *Opportunity Cards* were divided into three categories: *Content*, *Techniques* and *Organization* as these seemed to be the predominant themes dealt with on the cards and resulted in roughly equally large groups. Likewise, *Challenge Cards* were divided into *Physical* and *Digital* categories. *Question Cards* were not further subdivided into categories as they made up the smallest amount of cards and were originally envisioned as a subtheme of *Opportunity Cards*.

4. FINAL DECK OF CARDS

While naturally this paper cannot present all cards in full detail, they are described here as a brief overview. The deck of cards for the workshop consisted of 69 cards in total: 36 *Opportunity Cards*, 13 *Question Cards* and 20 *Challenge Cards*. The content of the cards were derived from previous work of the author and publications describing specific Mixed Reality games and lessons learnt from them as mentioned in section 2. Each card was 10.5cm tall and 7cm wide. Only the front side of the cards had information printed information on them – the back was kept blank.

4.1 Opportunity Cards

Opportunity Cards came in three different categories and therefore with three different background colors: *Content* (green), *Techniques* (red) and *Organization* (blue). The 36 *Opportunity Cards* made up a little bit over 50% of all cards used in the workshop. An *Opportunity Card* had the following structure: name, picture, summary, examples, considerations and ID (Figure 3a). The name appeared prominently at the top of the card and should be short, memorable and ideally very descriptive. The picture was used to make the card more memorable and illustrate the core concept of the card. The summary gave a short but more detailed description of the *Opportunity* that the card was about. Examples pointed to existing games that utilized this *Opportunity* and describe how it is applied there. Considerations provided additional ideas concerning the *Opportunity*. Lastly, the ID is used as a reference to the card, including the version number.

4.1.1 Content

Content Cards dealt with the look at feel of the game. How is the game content presented to the player? What kind of content is in the game? This included graphics, audio, user interfaces but also

how to deal with physical locations as part of the game. 10 *Content Cards* were used in the workshop:

Dominant Audio, Enabling Serendipity, Invisible Infrastructure, Large AR, Replayable Audio, Subverted location, Technical artifacts, Unusual Locations, Useful Props, Weather Input.

4.1.2 Techniques

Technique Cards mainly described the game mechanics and features of the game. How do players interact with the game, what are valid game actions and how is the game structured? With 15 different *Technique Cards* they made up the largest type of card in the workshop:

Asymmetric Gameplay, Automated Speed Limit, Chat Channel, Immobile Devices, Mini Games, Online Players, Peer-to-Peer, Player HQ, Seamful Design, Shared Devices, Simple costumes, Time limit, Time Triggers, Voluntary Speed Limit, Weekly Episodes.

4.1.3 Organization

Organization Cards look at the game from the game masters' perspective as well from a development point of view. What is needed during development and authoring of the game? What is happening when the game is being run? Is orchestration necessary and how is it organized? A total of 11 *Organization Cards* were used in the workshop:

360 Illusion, Algorithmic Locations, GM Intervention, In-situ Authoring, NPC actors, Pausing GPS, Simulated GPS, Tech Support, Tracking Players, User-created Missions, Wizard of Oz.

4.2 Question Cards

Question Cards were not further divided by category and have a turquoise background color. They were not further divided into categories. *Question Cards* dealt with questions the game developers/designers have to answer before being able to finish the design. The *Question Cards* sit between *Challenges* and *Opportunities* as they are neutral in spirit – they can be thought of as laying down the basic structure of the game. *Question Cards* had an identical layout to *Challenge Cards* as they were originally conceived a sub-group (Figure 3b). One distinguishing feature however was a rather large empty area at the bottom that could be used for notes on how to answer the question posed by the card.

13 *Question Cards* were given to the workshop participants:

Amount of Players?, Amount of Running?, Duration of Game?, Game Server?, Inside or Outside?, Location Dependency?, Location Selection?, Main Mechanic?, Multi- or Singleplayer?, Observation of Players?, Sensor Choice?, Size of Area?, Target Group?

4.3 Challenge Cards

Challenge Cards had been divided into two categories: *Physical* (yellow background) and *Digital* (purple background). 20 *Challenge Cards* were handed out to the workshop participants.

Challenge Cards mirrored the layout of *Opportunity Cards*. A picture, a summary, considerations and an ID followed the name and serve the same purposes (Figure 3c). They did not provide examples however as calling out games that suffer from these problems might be seen as too negative by the creators of those experiences. The black and white colors were inverted from the *Opportunity Cards* to further set them apart and make it easy to see which type a card was.

4.3.1 Physical

Physical Cards looked at problems the real world might cause for a game. How do outside effects (that cannot be controlled by the developers) affect the game? What are typical mistakes related to the environment that should be avoided in a game design? 10 *Physical Cards* were used in the workshop:

Location Dependency, Long Distances, Noise, Rain, Sunshine, Traffic, Uncontrollable Places, Uninteresting Locations, Worldwide Game, Wrong Direction.

4.3.2 Digital

Digital Cards talked about technologically challenges the game developers and designers might face. They were often based on imperfect devices and sensors. A total of 10 *Digital Cards* got used in the workshop:

Bad Content, Battery Life, Complex Interface, Effortful Testing, GPS and AR, GPS and Buildings, Orientation Loss, Unengaging AR, Unreliable Sensors, Unstable Connectivity.



Figure 3. a) Opportunity Card "Seamful Design", b) Question Card "Amount of Running?", c) Challenge Card "Traffic", d) Blank Opportunity Card.

4.4 Blank Cards

All categories of cards also came with a set of blank ones. These had no prewritten pattern on them but empty spaces instead, so that new patterns (or new ideas) could easily be written down and interacted with in the same way as the existing cards (Figure 3d). This was deemed as important as a pattern language is probably never fully complete – like spoken languages it is living and subject to change. Furthermore having to use only existing cards might have restricted brainstorming in an undesirable way.

5. WORKSHOP

5.1 Overview

The workshop “Mixed Reality Game Design and Development” took place at the University of Lincoln, United Kingdom, and lasted for two weeks. Students had to pre-register for the workshop and a total of 15 students participated (with different levels of engagement). The workshop was not part of the curriculum and was completely voluntarily: The students were not graded nor received any credits for their efforts. The participants consisted of first, second and third year students of the Games Computing and Computer Science Bachelor courses. 14 participants were male and 1 was female. During the workshop the students had full-time access to a lab equipped with Windows PCs. The actual game development was done using Android to which the students had received a one-day crash course a few days before the workshop. The workshop started on Sunday, October 27th 2013, with a half-day session and ended with final presentations of working game prototypes on Saturday, November 9th 2013.

On the first day students were introduced to the topic of Mixed Reality games by a one hour presentation, a discussion and a game of *Tidy City* with a mission tailor-made for the campus. Students then formed four groups of 3-5 students each in which they worked throughout the two weeks. One group got the chance to produce a game to be staged at the Museum of Lincolnshire Life, a local museum about commercial, domestic, agricultural, industrial and community life from 1750 to present day. Throughout the workshop, students were encouraged to come to lab sessions of about 1 to 2 hours where the progress of their game design and development was discussed and they would be given help and guidance. These sessions were organized roughly every other day of the workshop.

A total of three brainstorming sessions were supported with the pattern cards and described in the next sub-sections. In each of these sessions two groups of students were videotaped (not all students had given permission to be recorded) and unstructured notes from direct observations were taken as well as photographs. After each session students were asked to fill in questionnaires about the physical design of the cards, content of the cards, group interaction, usefulness of the cards and their experience in general. Some of the questions had to be answered on a 1 to 5 Likert scale while others were open ended. As not all students were present at all sessions the number of questionnaires filled in varies between sessions.

5.2 Brainstorming 1: Opportunity Cards

The first brainstorming session took place at the end of the first day of the workshop and lasted 25 minutes. Students were tasked to come up with an initial game design (Figure 4). Unlike the following sessions, this one had a set of rules on how the students were to use the *Opportunity Cards* they were given:

- Everybody draws 3 *Opportunity Cards*
- Draw a new card (or pick up a discarded one)
- Play a card on a stack (symbolizing a game)
- Describe how the card changes the game
- You can pass (discard all cards and draw 3 new ones)
- You can always use a blank card (and write on it)
- If there are [amount of players] cards in a stack, you can only play a new card by discarding one from the stack
- You can also start a new stack / game
- If you feel a game is “finished”, write down the design and discard the cards
- You are encouraged to discuss your ideas with the other players before playing a card / taking an action
- Make up your own rules

These restricting rules were mainly in place for the following reasons: a) ensuring that all students got to voice their opinions, b) limiting the games to a small set of core, defining features.



Figure 4. Brainstorming 1: Final selection of Opportunity Cards for one game design.

5.3 Brainstorming 2: Question Cards

On the second workshop day students were given the *Question Cards*. This time they were not restricted by specific rules. Instead they were asked to look at all the *Question Cards* and use the *Opportunity Cards* if desired to further define their game design (Figure 5). The focus was on making their initial designs playable and “cut” unnecessary features. This session lasted 50 minutes.

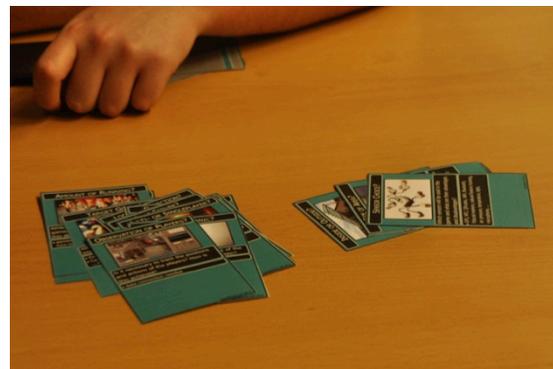


Figure 5. Brainstorming 2: Going through Question Cards.

5.4 Brainstorming 3: Challenge Cards

The final brainstorming session happened on day 4 of the workshop and lasted 25 minutes. Students were given the “missing” *Challenge Cards* and were asked to find holes and potential problems applicable to their current designs. In addition they were encouraged to make good use of the blank cards to write down any additional major challenges they might be facing (Figure 6).



Figure 6. Brainstorming 3: Interacting with Challenge Cards.

6. RESULTS

6.1 Games

Of the four groups participating in the workshop, two did not finish implementing their prototypes due to time constraints caused by other course work. The group working together with the Museum of Lincolnshire Life however finished two games, so that three games were presented on the final day of the workshop. In the following the 3 games that reached the prototype stage are briefly described as well as the 2 unfinished ones.

Museum Supplies is played in the large hall for vehicles in the Museum of Lincolnshire Life. The game starts at a WWI bunker where players use their NFC-capable phones to scan a tag and receive a mission: They are shown a picture and a historical hint about one of the many vehicles in the exhibition. They have to find the object in question and then scan the corresponding NFC tag hidden at the vehicle. In the story of the game, the players are transporting ammunition and in order to do so safely they can only move slowly while holding their phones level.

Museum Match 2 is played in an old classroom in the Museum of Lincolnshire Life. It is aimed at a younger audience. Players have to open the student's desks in which they find pictures of historical figures or events. Pointing their smartphone cameras at the pictures evokes an augmented reality representation of e.g. a moving windmill. They then have to find the matching other image to find all pairs.

Net Cheat is an asymmetric game in which a teacher walks around the campus while the other players are students trying to steal exam answers. The teacher's phone is emitting a Wi-Fi hotspot which the students try to connect to – if they manage to stay connected for a certain time without the teacher spotting them they acquire the desired answers.

Wizard's World did not reach a playable prototype stage. Players in the game become wizards that climb in ranks by defeating other wizards they meet in magical combat. These combats use a rock-paper-scissor mechanic based on 5 magical elements (earth, air, water, fire, mana). The power of an attack however depends on the amount and quality of the element in possession of the wizard.

Players can collect the different elements only at specific locations: mana elements spawn at locations like schools, libraries or universities for example. The position of these elements is not authored manually; instead the Foursquare API was intended to classify and identify locations.

RADIOactive did not reach a playable prototype stage. The game uses Wi-Fi signals to spawn radioactivity throughout the city. Players earn valuable artifacts by voyaging into the center of such radioactive areas; however the longer they stay and the stronger the Wi-Fi signals get, the more health points they lose.

6.2 Questionnaires

Students were asked to answer according to a 5-point Likert scale with 1 usually representing “I disagree” and 5 “I agree”. Table 1 shows a selection of questions. For each question the percentages for each answer are shown as well as arithmetic mean and standard deviation. The questions were designed to inquire about the general experience with the cards: if it was perceived to be fun, engaging and helpful. Other questions dealt more with the design of the cards itself and with the way and the amount of content presented. The goal was on the one hand to see if the cards were received in a positive light as well as to get feedback concerning a redesign of the cards. For brevity, not all questions are presented here but only the most interesting ones (several questions also asked for the same information but were phrased slightly differently).

Two questions asked about previous experience in playing (Q1) and developing (Q2) Mixed Reality games. 1 signified “no experience” and 5 “a lot of experience”. 12 students answered these questions.

12 students filled in the questionnaire after the first brainstorming session with *Opportunity Cards*. 25 questions were asked dealing with different aspects covering enjoyment, fun, usefulness, complexity and appropriateness (selection: Q3 to Q9).

15 students participated in the second brainstorming session that introduced them to the Question Cards. A total of 19 questions were asked (selection: Q10 to Q16).

In the last brainstorming session 10 students participated and answered 11 questions (selection: Q17 to Q23).

7. DISCUSSION

All student groups designed distinct and unique Mixed Reality games. Two of the four groups managed to develop working prototypes of their games during the workshop. Only two students stated that they had more than passing experience with playing Mixed Reality games while only one student had previously developed such games. The workshop participants can therefore be seen as inexperienced users who had no previous knowledge of the concepts presented by the pattern cards.

Concerning the amount and detail of the information presented of the cards, not all students agreed with each other. Q4 shows that about half of the students wanted more information on the *Opportunity Cards* while the other half wanted less. The level of detail for the game examples was deemed appropriate however (Q5, \bar{x} 2.5). When asked whether they wanted more information on the *Question Cards* the students rated the amount as appropriate. (Q15, \bar{x} 2.2). Similarly, the amount of information on the *Challenge Cards* was seen as sufficient (Q19, \bar{x} 4.6). Using the cards sparked discussions between the group members as evidenced by very strong agreement with Q7 (\bar{x} 4.75) and Q22 (\bar{x} 4.5). While *Opportunity*, *Question* and *Challenge Cards* followed different concepts, workshop participants saw them as working

well together (Q13 with \bar{x} 3.73 and Q20 with \bar{x} 3.90). When looking at the *Opportunity Cards*, they were rated as easy to understand (Q3, \bar{x} 3.92) and very helpful for brainstorming (Q6, \bar{x} 3.92) – but the students would have liked more of them (Q8, \bar{x} 4.5). The *Question Cards* helped students to focus (Q11, \bar{x} 3.47) as well as fleshing out their designs (Q10, \bar{x} 3.73) and introduced new aspects not yet covered by the *Opportunity Cards* (Q29, \bar{x} 3.87). In contrast to the amount of *Opportunity Cards* not being sufficient, students thought there were enough *Question Cards* (Q14, \bar{x} 3.2). The *Challenge Cards* were seen as relevant for the specific games (Q17, \bar{x} 3.8) and – and even more unambiguously as educational (Q18, \bar{x} 4.3). Most students however thought that the *Challenge Cards* were introduced too late in the overall schedule of the workshop (Q21, \bar{x} 3.6). Lastly, students clearly enjoyed using the cards as illustrated by their answers to Q9, Q16 and Q23 with arithmetic means of 4.17, 3.93 and 3.90 respectively.

8. CONCLUSION AND FUTURE WORK

In summary, the *Pattern Cards* have been well received by the workshop participants. They rated the content of the cards helpful and the amount of information on each card as adequate. This is interesting to note, especially when comparing them to the deck of sound pattern cards that feature a lesser amount of descriptive texts. In general the interaction with the cards was seen as fun and encouraged discussion. Further evaluation needs to be done concerning the different types of cards, and especially about the best timing to confront users with the cards: gradually over time like in this study or instead all at the same time? The cards seemed well suited for restrictive rules (brainstorming session 1) as well as open interactions (brainstorming sessions 2 and 3). The workshop participants did not use the blank cards at all – potentially because they were newcomers to the whole idea of Mixed Reality games and therefore had little pre-existing knowledge. Using the *Opportunity* and *Question Cards* during the early stages of the creative process seems to be an approach that makes sense. The *Challenge Cards* however are potentially also interesting to be used when a game prototype already exists to

Table 1. Selected questions from the questionnaire.

Question	1	2	3	4	5	\bar{x}	σ
Q1: Before the workshop, I had the following amount of experience PLAYING Mixed Reality games:	67%	17%	0%	17%	0%	1.67	1.11
Q2: Before the workshop, I had the following amount of experience DEVELOPING Mixed Reality games:	92%	0%	0%	8%	0%	1.25	0.83
Q3: The cards were easy to understand.	0%	8%	17%	50%	25%	3.92	0.86
Q4: I would have liked more information on the cards.	17%	42%	0%	42%	0%	2.67	1.18
Q5: The examples on the cards were not detailed enough.	33%	8%	33%	25%	0%	2.5	1.19
Q6: The cards were very helpful for brainstorming.	0%	8%	25%	33%	33%	3.92	0.95
Q7: The cards encouraged discussions with my other group members.	0%	0%	0%	25%	75%	4.75	0.43
Q8: I would have liked to have more cards.	0%	0%	0%	50%	50%	4.5	0.5
Q9: I enjoyed using the cards.	0%	0%	25%	33%	42%	4.17	0.8
Q10: The cards were very helpful in further fleshing out the game design.	7%	7%	27%	27%	33%	3.73	1.18
Q11: I think the Question Cards helped me focus.	7%	20%	13%	40%	20%	3.47	1.2
Q12: The Question Cards made me think about things I hadn't considered previously.	7%	13%	13%	20%	47%	3.87	1.31
Q13: The Question Cards worked well together with the Opportunity Cards.	0%	0%	53%	20%	27%	3.73	0.85
Q14: I would have liked more Question Cards.	7%	27%	20%	33%	13%	3.2	1.17
Q15: I would have liked more detail on the Question Cards.	33%	27%	27%	13%	0%	2.2	1.05
Q16: It was fun working with the cards.	0%	7%	33%	20%	40%	3.93	1
Q17: The Challenge Cards were relevant for our game.	0%	20%	20%	20%	40%	3.8	1.17
Q18: I learned a lot about typical problems of Mixed Reality games by using the Challenge Cards.	0%	0%	10%	50%	40%	4.3	0.64
Q19: The information on the Challenge Cards was sufficient.	0%	0%	0%	40%	60%	4.6	0.49
Q20: The Challenge Cards worked well together with the Opportunity Cards.	0%	10%	10%	60%	20%	3.9	0.83
Q21: I would have liked to use the Challenge Cards earlier in the brainstorming process.	10%	0%	30%	40%	20%	3.6	1.11
Q22: The Challenge Cards led to productive discussions in the group.	0%	0%	10%	30%	60%	4.5	0.67
Q23: It was fun using the Challenge Cards.	0%	10%	20%	40%	30%	3.9	0.94

help identifying problems of the game. This approach was however not tested during the described workshop (mainly due to issues related to the overall organization), but could be a promising angle to explore.

So far only one workshop has been undertaken with the pattern cards and it still remains to be fully analyzed. The answers to the open questions will result in more qualitative data as they allowed participants to criticize specific parts of the workshop and the cards. An in-depth look at the video recordings of the sessions will most likely result in further valuable feedback, especially on how the participants interacted physically with the cards. How were they placed on the table? Were they moved around a lot? How often were they picked up and inspected?

The chosen categories for each type of card are another interesting point of further evaluation as one could probably make a case for different groupings. Similarly, at the moment the categories are chosen by theme, but another way to divide them could be by hierarchy (e.g. from high-level to low-level concepts).

One common attribute of pattern languages is also the connections between different patterns. In the current version, the cards do not explicitly cross-reference each other. The main reason for this was a lack of space (mentioning all connections could easily get very exhaustive). In addition, any links would also require a user to search through the whole stack to find a named card which is way less convenient as can be done in a wiki. As the cards are also mainly aimed at sparking creativity such direct relations might also inhibit users from coming up with their own and unusual solutions. These are questions that have to be answered during an upcoming redesign of the cards as well as the role of their backside that so far is blank.

Furthermore the content of the current set of cards needs to be validated by more experienced users while at the same time new ones should be developed to extend the existing base. This will be done by e.g. more in-depth analysis of related work as well as existing games and interviews with academic and industrial experts in the field.

Another additional next step will be to use the pattern cards with more experienced users to evaluate their usefulness in such a scenario.

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