Concepts and Mechanics for Educational Mini-Games

A Human-Centred Conceptual Design Approach involving Adolescent Learners and Domain Experts

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***Abstract* — This article reports on two conceptual design sessions in which concepts for educational mini-games were generated through a human-centred approach. First, co-creation sessions were held with 14 adolescents between 14 and 16 years old in order to gain insight into their preferences for educational games for language learning. During these sessions, 11 game concepts were generated, revealing a classification of concepts for games oriented towards, on the one hand, formal language learning and, on the other hand, more informal communication with other players or in-game characters. Second, brainstorm sessions were organized with six domain experts in order to reveal which mechanics are most appropriate for the design of mini-games for a variety of educational programmes. These sessions resulted in 28 ideas reflecting three game mechanics particularly suited for educational mini-games tailored to adolescent learners.**

Keywords – mini-games; serious games; human-centred; conceptual design

I. INTRODUCTION

Nowadays, video games are no longer designed solely for entertainment purposes. The continuously increasing interest in serious games and gamification has shown that many areas can benefit from the engaging experience that video games offer. For instance, video games have been designed to help people in various therapeutic contexts [22], [56], as well as for educational purposes [47], [50], [54]. In the field of Computer-Assisted Language Learning (CALL), particularly, games have long been developed specifically for language instruction [26], [28], [45], and games have, to a more limited extent and much more recently [11], been subjected to empirical research on issues related to language development [13], [37], [42], [52].

One reason why games may be particularly suited for educational purposes is that many aspects of video games, for instance problem/puzzle solving and assessment, are also present in formal educational settings. Besides the potential of serious games to provide engaging learning experiences, previous work has shown that it is hard to bring this into practice.

More particularly, on the one hand, it has been recognized that it is challenging to ensure the effectiveness of serious games, e.g., in terms of knowledge acquisition, increased motivation or improved attitudes [41], [58]. On the other hand, many serious games have been criticized for being unable to provide compelling game experiences, thereby failing in achieving their entertaining goals [15], [29], [39].

From the perspective of the player, certainly if playing voluntary, gaming is an end in itself rather than a vehicle to learn (e.g., learn a new language) or achieve goals outside the game (e.g., live healthier) [25]. Arguably the player is ideally intrinsically motivated to play a serious game, instead of using a game to obtain an extrinsic serious goal.

Although many researchers have analysed game players' intrinsic motivations [3], [35], [36], [48], [49], [59], [61] and the design aspects that deliver engaging game experiences [21], [24], [30], [31], [32], there is still a gap in research on the design concepts and methods needed to reconcile the seemingly contradictory design goals of serious games [58].

This article addresses the challenge of how one can design serious games that are both fun and effective. In particular, the conceptual design of educational mini-games as a complementary means to the instruction in class is focused upon. Overall, mini-games are defined as small, self-contained games that usually take a short amount of time to complete and focus on a specific topic; mini-games are ubiquitous, and have been developed for several purposes, including education [17].

In this article, the typical human-centred design approach is first described in order to frame the activities of our study. Then, the research goals are specified. Further, the method and results of two conceptual design sessions are elaborated upon; this includes, firstly, the co-creation session with end-users and secondly, the brainstorm session with domain experts. Then, the results of both sessions are discussed. This article ends by summarizing the scientific contribution and delineating areas for further work.

II. RELATED WORK

The International Standardization Organization (ISO) has defined five major steps in the human-centred design process of interactive systems, in which continuous iteration is encouraged between phases of understanding and specification of the context of use (predesign), understanding and definition of user requirements (conceptual design), the production of design solutions that meet the defined requirements (design and development) and an evaluation of these designs against the requirements (evaluation*)* [27]. This process has been referred to as the "ISO9241-210 standard of Ergonomics of human-system interaction; Human-centred design for interactive systems" [27]. It relies on four basic principles, i.e., 1) active involvement of users and a good understanding of the needs of users and tasks, 2) adaptation of technology to the user, 3) iterative design, and 4) a multi-disciplinary design team.

In digital game development, human-centred design has mainly been advocated as involving players in play tests from the very moment that the first prototypes have been created [38], [43], [58]. Although this type of play testing does involve players in the evaluation phases of the (late) design process, players and stakeholders are rarely offered the opportunity to participate in predesign and (conceptual) design phases.

In excluding the eventual players from bringing in input in the early concept and design phases, game designers are likely to end up with a self-referential design, one that is oriented towards the needs and preferences of the designers rather than being tailored to the particular target group. Such an 'I'-methodology should be avoided, especially when the target audience of the game differs from the developers/designers. Besides, the game design process not only benefits from input provided by target users, but also from input given by domain experts, especially when the ambition is to reconcile entertainment and serious goals [57].

This article focuses upon a study that followed a human-centred game design process. More particularly, the results of two conceptual design sessions are reported upon. The overall research goal of the sessions was geared towards a first understanding and specification of the context of use and the definition of user requirements for educational mini-games tailored to adolescent learners. These research goals corresponded with the conceptual design phases of ISO's human-centred design process, as described earlier in the article.

As for the first conceptual design session, target users were actively involved in the idea generation of mini-game concepts for second language learning. There are several ways in which end-users can be involved in the initial phases of the design process [4], [16], [18], [34], [60]. In our study, generative techniques for idea generation were focused upon. These techniques typically rely on the creation of artefacts together with end-users, an approach that in literature is referred to as co-design or co-creation. The central notion is that the people destined to use the product play a critical role in conceptualizing and designing the product [46].

Co-creation is based upon the premise that human beings' knowledge, feelings and dreams are hard to uncover as this information may not readily be expressed in words, or cannot be observed as it might, for instance, be about latent needs. Generative techniques or 'make-tools' are needed then to facilitate the expression and communication of thoughts, feelings, and dreams. The act of physically laying out words, images and constructing representations of ideas enables the participants to articulate their ideas more thoroughly than they are able to in a typical interview or conversation. Consequently, the reflexivity through the act of creation then serves as an explanatory vehicle for their needs and ideas, not as a concrete visualization of the final design specifications [23], [44].

Although the method and the results of this first conceptual design session have been described in a previous publication, presented at the ACHI 2012 conference [1], this article provides an extended reflection by the inclusion of new empirical data that were gathered during a second conceptual design study. Conceptual design typically follows an incremental process, and hence it benefits from alternation of idea generation phases, especially when several multidisciplinary views and a variety of stakeholders are brought together.

Therefore, during the second session, domain experts - including both game designers/developers and educational experts- were asked to brainstorm and reflect upon mini-game concepts that would be transferable to a variety of domains other than language learning, including mathematics, history and geography. The development of educational games poses real challenges in terms of the return on investment. That is why the conceptualization of more generic mini-game concepts was considered to be very important because it allows mini-game concepts to be re-used for several educational domains with relatively little effort and cost.

The brainstorm session with domain experts was organized according to the evolutionary approach towards design thinking, in which phases of diverging (i.e., creating choices) and converging (making choices) are typically separated and alternated [8]. In particular, the creation of ideas in multidisciplinary teams was stimulated in order to broaden the space of possibilities.

To facilitate the idea generation process, several recombination and mutation rules and techniques were relied upon. For instance, domain experts were encouraged to express themselves visually and come up with wild ideas [53]. Additionally, the participants were encouraged to produce many ideas in order to get as many ideas from the workshop as possible. This was important because it has been found that discussing multiple brainstorming outcomes is more effective than considering a single artefact when it comes to avoiding fixation [19], richer design outcomes, better idea exploration, sharing, and group rapport [14].

III. CO-CREATION WITH END-USERS

In the following paragraphs, the first conceptual design session, the co-creation with end-users, is described in detail, including the participants and procedure, and followed by a discussion of the results.

A. Method

1) Participants

A total of fourteen adolescents participated in the co-creation session. The group was divided into two subgroups; each subgroup participated in one co-creation workshop. The first workshop was organized with eight adolescents in the morning; the other workshop, consisting of six adolescents, took place in the afternoon.

All participants were between 14 and 16 years of age, only one of the 14 participants was a girl. Twelve were in general secondary education, two participants were from technical secondary education. The eight participants of the first workshop played on average 41 minutes a day; the six participants of the second workshop played on average 1 hour 35 minutes. The participants were recruited through online forums, electronic newsletters, paper flyers and posters. Although the aim was to recruit a group of adolescents that was evenly divided in terms of gender, education and game preferences, there was an overrepresentation of boys from general secondary education who play games on a regular basis.

2) Procedure

The morning and afternoon workshop lasted each approximately three hours. Each workshop consisted of an introduction, group discussion, game design round, and a final group discussion. By following these steps, we aimed to follow the typical cognitive process of creativity closely. This process is typically divided into four or five stages, including the sensitization of the problem space, incubation, inspiration and transformation stage [5], [9], [12]. These stages will be referred to in more detail below.

Introductory round: Using a slideshow presentation, the topic at hand and the co-creation methodology were explained. Then, results from previous co-creation workshops were presented. These examples were taken from domains other than language learning, in order to prevent possible bias in the creative thinking of the participants. The introduction took around 15 minutes.

Group discussion: After the introduction, the group was split into smaller subgroups. Two researchers joined each subgroup and started a short, moderated group discussion. The aim was to better understand the envisioned context of use and the end-users, which is necessary to define requirements for the design of new products [27]. More particularly, the participants' current language learning practices -both formal and informal- and their general experience with learning through games were addressed. Additionally, this group discussion was also intended as a 'sensitizing activity', which is a typical first stage in a creative process of idea generation [5], [51]. This group discussion lasted approximately 20 minutes.

Figure 1. Co-creation session in which low-fidelity prototypes of video games were created.

Figure 2. Prototype presentation and group discussion.

Game design round: Given the time of about one hour, each subgroup was asked to come up with game concepts and create low-fidelity paper prototypes of these concepts using the available materials (see Figure 1).

The creation of at least three prototype artefacts was encouraged as it has been found that creating multiple prototypes is more effective than creating a single prototype when it comes to the design outcomes, exploration, sharing, and group rapport [14].

Note that the prototypes by no means had to be complete designs, but rather served as vehicles to express and discuss ideas, needs and preferences. Further, the participants were not constrained in the creation and conceptualization to mini-games only; they were given the opportunity to think freely about a variety of game concepts for language learning instead. Only when a group of participants had come up with two concepts that were clearly regular video games instead of mini-games, the researchers encouraged the participants to think of their next game concept as a mini-game.

When looking at the different stages of the creative process of idea generation and design thinking, the game design round resembled the third stage, inspiration [44]. In this stage, possible solutions or new insights typically occur. The incubation stage was not present in our study due to practical concerns, as the workshops were scheduled on one day. Such an incubation stage typically occurs after sensitization of the problem stage and before inspiration, and allows the participants to set the problems aside for a time.

Final group discussion: After the game design round, participants presented their prototypes to each other and the researchers (see Figure 2). Participants could ask questions, comment on the prototypes and ideas, and judge the appropriateness and potential of the presented concepts. The researchers moderated this discussion, probed for more clarification with respect to certain design choices, as well as regarding a number of pre-defined topics, questioning for instance the user-oriented and personal goals of the game concepts, the role of the teacher, or the envisioned context-of-use.

Note that the group discussion was considered as an activity that represents the final stage in the creative process, i.e., transformation [9]. This stage foresees in an evaluation of the value of ideas (e.g., group discussions) and decision (e.g., via rating) with regard to the idea selection. In our study, this transformation phase lasted about an hour.

B. Results

The co-creation workshops with end-users resulted in a total of 11 game concepts. Four of the eleven games had a multiplayer mode. Six of the games incorporated a social component, like the ability to share high scores with friends, and communicate via voice chat. The choice of the platform (computer, console, mobile) was not specified for most game concepts. Some games were thought to be more suited for a specific platform than others, with game concepts ranging from a traditional mini-game on a desktop computer, to an augmented reality game on a mobile phone. Further, the results revealed a wide range of reward mechanisms, from simple scoring systems such as traditional high scores to more complex rewarding mechanisms, whereby the player gains experience points on different levels. The participants also indicated that in-game feedback mechanisms were of considerable importance. The participants agreed that the mini-games for foreign language learning should provide some kind of feedback mechanism that helps players when they are stuck, such as for instance, a built-in translator to an in-game character that aided the player as an interpreter for foreign languages.

Overall, the results revealed two main categories of game concepts for language learning, including games for formal learning on the one hand, and games in which language serves as a means of communication on the other hand. In what follows, a more detailed overview of these two categories is given.

1) Games for formal language learning

The co-creation sessions revealed three game concepts that were aimed towards formal language learning. These games shared a focus on vocabulary, were similar in terms of immediate feedback, required limited time to play, and contained little or no narrative. The latter characteristics will be outlined based on one game concept that was developed during the co-creation workshops, namely the cannon-versus-monsters game (see Figure 3).

In this game, the player has to translate a word as quick as possible in order to prevent monsters, descending on a narrow path, to reach the player. The number of bullets a player receives depends on the length of the assigned word. For instance, a four-letter word that is correctly translated gives the player four bullets to eliminate the approaching monsters. The difficulty level of the game gradually rises with each stage, offering the player not only more challenging words to translate, but also more bullets and useful power-ups -any item that temporarily gives a character new abilities, new powers, or a statistical bonus.

Feedback in the cannons-versus-monsters game is provided immediately. Every time the player fails to translate a word, the monsters come closer to the player's home, eventually destroying it when the monsters come near enough. The player should thus try to translate as many words as possible in a correct way. When the player fails to translate a word, the consequences are instantly visible as the monsters further approach the onscreen character of the player.

The cannon-versus-monster game revolves around the relatively simple goal of keeping the monster away. By translating words correctly ammunition is earned that can be used to shoot the monsters. No further narrative or plot was provided as context for the game. The cannon-versus-monsters game concept concerned a simple and short game; it did not require a lot of time to complete. Therefore, the participants argued that the game could be played in situations in which little time is available, e.g., at home for schoolwork or even at school as part of language learning classes.

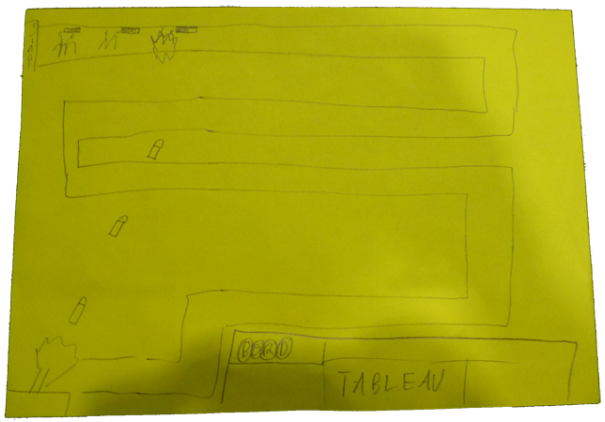

Figure 3. Drawing of the cannon-versus-monsters game concept.

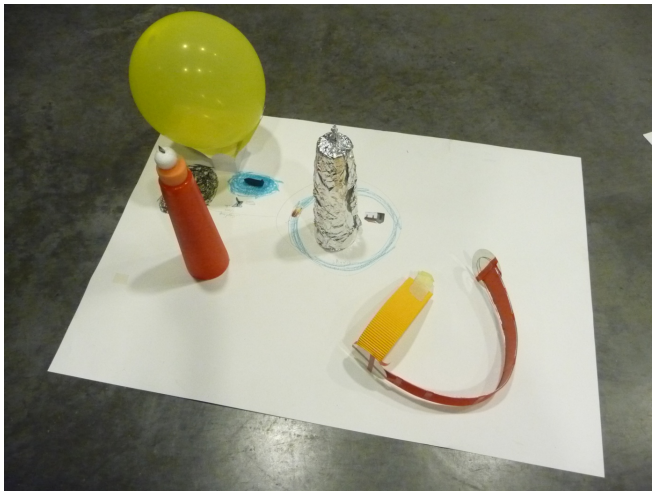

Figure 4. Creation of the adventure game.

2) Games and language as communication

The majority of ideas could be characterized as presenting a game concept in which language is used as communication. In total, six game concepts could be characterized by their focus on language as a means to communicate in the game. Players needed to communicate to progress through the game. When compared to the three game concepts that focused on vocabulary, these concepts were characterized as being more complex, containing an elaborate narrative, providing less immediate feedback, and being more time consuming. In what follows, the characteristics of the latter category of game concepts will be explained by looking at one of the six game concepts, an adventure game, in more detail (see Figure 4).

The adventure game starts from a story in which the player has to get from Paris, France, to Los Angeles, USA, to visit his or her sick mother. To achieve this, the player has to communicate with other game characters or other non-player characters. Thus, language is the means to get to the end goal. Through dialogues and creative use of language (e.g., asking for a lift, lure opponents into traps, persuasion, deceiving, etc.) the game character progresses through the game.

Overall, the results showed that the game concepts that focused on communication were more elaborate than the game concepts that focused more explicitly on linguistic sub-domains, such as vocabulary. The narrative was very important and much richer in the games focusing on communication. Consequently, feedback was thought of in a less immediate way than in the games that focused on vocabulary.

For instance, while in the cannon-versus-monsters game, the player immediately receives bullets to keep the monsters away, or sees the monsters approaching further after each mistake; the progress in the games focusing on communication was less immediately visible. Although the end goal was clear, the player was only considered to slowly approach the goal; and in this process the rewards were more high level.

Finally, compared to the games focusing on vocabulary, the game concepts with a focus on communication were relatively complex and therefore required more time to play. To engage in the game concepts, players would need a period of uninterrupted time available to play. This would make these games, according to our participants, more suited for playing at home, and less suited for class use.

IV. BRAINSTORM WITH DOMAIN EXPERTS

In the next paragraphs, the participants and procedure of the brainstorm session with domain experts is described, followed by a discussion of the results.

A. Method

1) Participants

Three game designers/developers and three educational experts were invited to participate in the brainstorm session. These domain experts were divided in three subgroups of two people, one game expert and one educational expert. Figure 5 shows an impression of the brainstorm session in small subgroups.

2) Materials

The domain experts were provided with three kinds of materials as input for the workshop in order to facilitate the brainstorming process; they were not forced to use these materials.

Firstly, each subgroup received five random cards from the Game Seeds© card deck [55] (see Figure 6). These cards visually represent game mechanics as well as some playful rules that can be used to turn a brainstorming exercise into a playful activity. Even though the participants did not have to engage in the entire Game Seeds© brainstorming game, the visual presentation of game mechanics on the cards was considered to impose additional constraints that could increase creative thinking.

Secondly, to encourage domain experts to generate game concepts for a wide range of educational purposes, sheets with written topics that typically constitute the subject matter of adolescent-oriented class courses on geography, history, mathematics and language learning were handed over. Again, these sheets were shown for inspiration purposes only; domain experts did not need to rely on this information.

Thirdly, personas were given as input to the brainstorm in order to further improve the idea generation process. Personas represent fictive characters that are based on factual information. In human-centered design, personas are utilized to present a reflection of the (hypothetical) archetypal user. Additionally, personas are also considered useful as a method to make a design team empathise with the product's end-users thanks to a deeper understanding of their likes and dislikes, and their capabilities [2], [10], [40].

Figure 5. Brainstorming session with domain experts.

Figure 6. Game Seeds© cards, used as input for the brainstorming method. The visual representation of concrete game mechanics presented constraints that were deliberately imposed to increase the likelihood of creative design thinking.

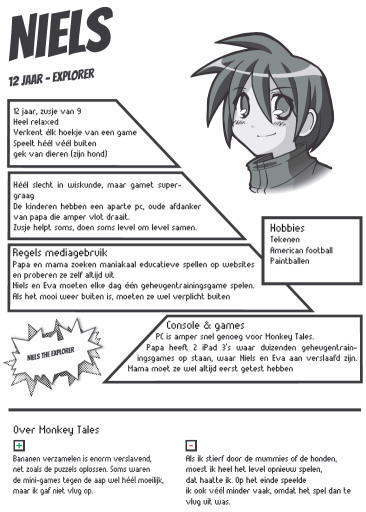

Figure 7. Extreme persona (Dutch), used as input for the brainstorm session with domain experts, as a means to create empathy with the end users and stimulate creativity during the idea generation process.

In our study, the personas resulted from the insights gained in a diary study that preceded the brainstorming session. In the diary study, eight households with adolescents were selected to report on their behaviour and experiences with Monkey Tales©, an educational game for training mathematics [33], for a period of two to three weeks. The results were summarized in 'extreme' personas that enlarged the players' general characteristics and reported in an exaggerated way their likes and dislikes, the media rules of the household, their game preferences and experiences. For an example of such an extreme personas (in Dutch), we refer to Figure 7.

The advantages of brainstorming with extreme inputs that are based on evidence-based personas are twofold. First, personas have been found to provide a powerful means to communicate relevant user characteristics to help a product design team to empathize more with the envisioned end-users [2], [10], [40]. Secondly, the power of the reflection on extreme stimuli has been recognized as showing great promise to increase the creativity during idea generation phases in user-centred design [6], [7], [19].

3) Procedure

The procedure consisted of three rounds of brainstorming in pairs followed by evaluative, plenary discussions of the value of the ideas. After each brainstorming and discussion round, new pairs were formed and a new round of brainstorming and evaluative discussion was started. In each round, the dyads received a new combination of input materials, including a persona, five randomly assigned game mechanics and a new educational topic.

In total, the brainstorm lasted approximately two hours and 30 minutes.

B. Results

The brainstorm session with domain experts generated 28 ideas that reflected three different types of educational mini-game concepts. The first category concerned the 'Matchers', characterized as those mini-game concepts in which players are challenged to combine several related things such as words, numbers, images or topics. The majority of the game concepts generated during the brainstorm session could be classified as a Matcher. The second category encompassed the "Sorters". These concepts shared the common idea that things can be ordered on a timeline or map. The third main category of game concepts revolved around Multiple Choice (questions). It should be noted, though, that some game concepts could not be classified into one of these three aforementioned game categories. In sum, the analysis of the game concepts revealed the following classification: a) Matchers, b) Sorters, c) Multiple Choice and d) Others.

The constraints of this article do not allow us to elaborate upon each single idea that was generated during the brainstorm. Consequently, we will select one game concept for each category and discuss it in more detail.

1) Matchers

In total, the brainstorm session resulted in 16 Matcher game concepts. To exemplify this, we will report upon the 'Snowlines' concept. Figure 8 shows the concept drawing as it was sketched and presented during the brainstorm session.

The idea of 'Snowlines' is that by snowboarding/skating/skiing through the gates the player needs to select the words or items that are related to each other. There are several routes that are allowed/correct; some are more optimal than others and by choosing or combining the right gates, more or less points can be collected. The learning concept relies on the ability to group similar words, items, topics, verb conjunctions etc. The underlying game mechanic is based on selection and grouping. For this concept, one might think of additional features to enhance the playability, such as doing tricks in between two gates.

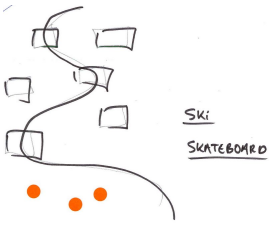

Figure 8. Concept sketch 'Snowlines', a Matcher game concept.

2) Sorter

Four Sorter game concepts were generated. One of these Sorters was the 'Character-Map Exploration' game, depicted in Figure 9. In this game concept, players would receive an inventory of characters, of which some are locked, and some are not. The players would then need to interview these characters to get to know them. Based on the information revealed by the characters, players would be able to place the characters on the correct spot on the map. According to the domain experts, linking characters and their items with the corresponding country and locating this country, the players might eventually learn about historical people, their stories and locations.

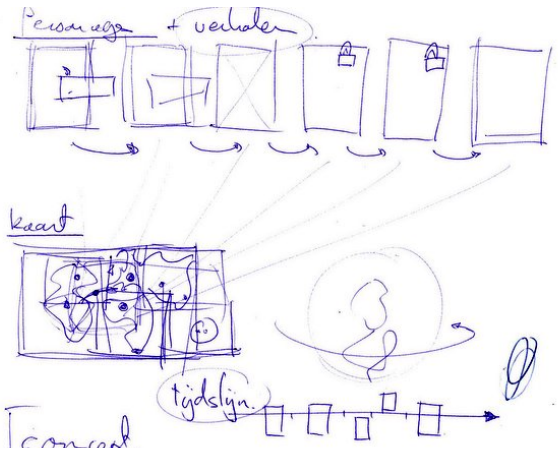

Figure 9. Concept sketch 'Character-Map Exploration', a Sorter game.

3) Multiple Choice

The brainstorm session resulted in two multiple Choice game concepts. Figure 10 shows the concept sketch of one of these, namely the 'Save the Princess' game. The game concept resolved around the challenge of saving a princess and finding your way through a labyrinth. By choosing the right door/way, the player would select the correct answer. Behind the wrong doors/answers, there is the risk to be confronted with deadly monsters. Everywhere in the labyrinth the player might engage in finding clues and hints to help find the correct way.

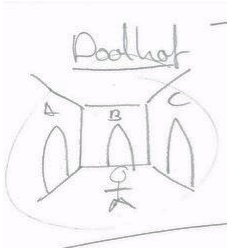

Figure 10. Concept sketch 'Save the Princess', a Multiple Choice game.

4) Others

Six concepts could not be classified in one of the categories above. Examples were the 'Search the 7 Mistakes' in which players had to select things that are wrong in an image, and the 'Draw and Guess' game concept in which players would have to guess the specific word from his or her teammates' drawings. These two game concepts are represented in Figure 11.

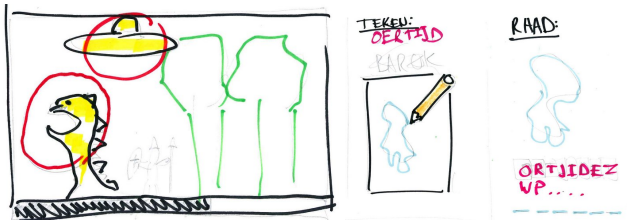

Figure 11. Concept sketches 'Search the 7 mistakes' (left) and 'Draw and Guess' (right).

V. DISCUSSION

A variety of ideas were generated during the brainstorming session with domain experts and during the co-creation workshops with end-users, showing considerable promise on the basis of which both fun and effective educational mini-games can be designed.

The results of the co-creation with end-users point towards two directions that can be chosen in the design phase of educational games for language learning. On the one hand, the participants considered the potential of games for formal language learning that resembled the definition of a mini-game. It should hereby be noted that these formal language-learning exercises were related to learning vocabulary; none of these game concepts dealt with grammar. It is unclear, however, whether this is the result of a lack of interest or the adolescent participants' lack of capability to consider grammar-related game concepts. On the other hand, when it comes to language as communication, the participants preferred more complex games with a narrative, which confirms that games can be used as a medium to create a need for the language learner to accomplish objectives that lie outside the language itself. Nevertheless, many of this type of game concepts resembled existing games. It is not clear whether this fixation upon existing game concepts resulted from methodological decisions, the participants' characteristics, or from the combination of both aspects. In order to potentially be able to answer this question, we would advise future research to link the participants' gaming history and pre-existing preferences to the creation of game concepts in co-creation sessions and experiment with a wider variety of idea generation techniques.

Secondly, when it comes to the ideation of mini-game concepts that can be used for several exercises in a variety of instructional domains other than language learning only, the results suggested that Matchers, Sorters and Multiple Choice game mechanics are most promising to be included in educational mini-games. We are convinced that the generic character of these game concepts may bring an important advantage for game developers or publishers who want to wisely invest in educational mini-games.

There are some issues that remain unsolved, though. For instance, it is not clear why the brainstorm session mainly revealed Matcher concepts. At this point, it is unclear whether this is due to a lack of a better classification, or whether it is just easier to generate ideas about Matcher game concepts; or if there are even other reasons involved. Moreover, it should be noted, that the categorization of Matchers, Sorters and Multiple Choice educational game mechanics does not differ that much from the classical e-learning approaches that also typically rely on matching, multiple choice and sorting. In this context, our results clearly indicated that the 'packaging' of the exercises provided the mini-games with an additional layer of fantasy that increased the game experience (e.g., story, characters and missions.

Another issue with respect to the brainstorm session with domain experts concerns the usefulness of the input materials, i.e., the personas, the Game Seeds© and the instructional examples. To our knowledge, there is no previous work in which the combination of these input materials have been employed. Consequently, it is unclear what the effect is of the methodological decisions upon the brainstorm outcome.

The last issue of our discussion is relevant for both the co-creation and brainstorming session. It should be stressed once more that the results were not intended to represent finished game concepts or concrete design guidelines. The results provide the design team with more insights into the users and their preferences, information that should be complemented with for instance the insights revealed through contextual observations. When the design team understands the users and the context of use, inspiration can be drawn from the created artefacts (co-creation workshops) and presented sketches (brainstorm session) in the further development from low-fidelity to high-fidelity prototypes. As the ISO 9241-210 human-centred design process prescribes, phases of development and human-based evaluations should sufficiently iterate in order to optimize the end product. Hence, the designers can put their own expertise in developing the designs, being inspired but at the same time not limited by the artefacts that were created during the brainstorm and co-creation sessions. The design team should hereby acknowledge that the products have to be re-evaluated in several iterations by directly involving the stakeholders, i.e., the end-users in the first place.

VI. CONCLUSION AND FUTURE WORK

This article reported upon two conceptual design sessions in which a human-centred approach was followed to gather requirements and inspiration for the design of mini-games with educational purposes tailored to adolescent learners.

Firstly, co-creation workshops were held with adolescents in order to reveal their ideas, needs and preferences with regard to video games for language learning. The results showed a divide between the concepts for mini-games that were oriented towards formal language learning (e.g., exercises on vocabulary) on the one hand and video games that were based on communication with others (players or in-game characters) on the other.

Secondly, brainstorm sessions were held with domain experts, including game designers/developers and educational experts, to generate ideas and gather requirements for the design of mini-game concepts with educational goals. The results revealed a categorization of educational mini-game concepts with sufficient potential to be both fun and efficient, including Matchers, Sorters and Multiple-Choice concepts. The Matchers seemed most promising, not only did this category generate most ideas, it also turned out to be most promising to be applied in a variety of educational programs ranging from mathematics to language learning, geography and history.

To conclude, the two conceptual design sessions described in this article resulted in a divergence and multitude of rich ideas. Nevertheless, more design iterations are needed to evaluate these ideas by making choices in terms of the most promising ideas. By no means are the conceptual design sessions imposing final solutions. As described by the ISO's human-centred design process, more iterations and empirical evaluations are needed in the subsequent detailed design and development phases. Consequently, future work should focus on the next human-centred design steps and report which design decisions are to be taken to realize successful educational mini-games that are tailored to adolescent learners; mini-games that reconcile both entertaining and educational goals.

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REFERENCES

[1] Poels, Y., Annema, J.-H., Zaman, B., and Cornillie, F. "Developing User-Centered Video Game Concepts for Language Learning," ACHI conference, 2012, pp. 11–16.

[2] Antle, A.N. Child-personas: fact or fiction?" Proceedings of the 6th conference on Designing Interactive systems (DIS 06), ACM, 2006, pp. 22–30.

[3] Bartle, R. "Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDS," 1996, http://www.mud.co.uk/richard/hcds.htm [last accessed Dec 2012].

[4] Beyer, H. and Holtzblatt, K. "Contextual Design: Defining Customer-centered Systems," Morgan Kaufmann, San Francisco, CA, 1998.

[5] Boden, M.A. "Creative Mind: Myths and Mechanisms," Routledge, New York, NY, 2003.

[6] Bowen, S. "Getting it Right: Lessons Learned in Applying a Critical Artefact Approach," In: Undisciplined! Design Research Society Conference 2008, Sheffield Hallam University, Sheffield, UK, 2009.

[7] Bowen, S.J. "Crazy ideas or creative probes?: presenting critical artefacts to stakeholders to develop innovative product ideas," Proceedings of EAD07: Dancing with Disorder: Design, Discourse and Disaster, Izmir, Turkey, 2007.

[8] Brown, T. "Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation," HarperBusiness, 2009.

[9] Bullinger, H.-J., Müller-Spahn, F., and Rössler, A. "Encouraging Creativity - Support of Mental Processes by Virtual Experience," Conference Virtual Reality World, 1996.

[10] Cooper, A. and Reimann, R.M. "About Face 2.0: The Essentials of Interaction Design," Wiley, 2003.

[11] Cornillie, F., Thorne, S.L., and Desmet, P. "Editorial. Digital games for language learning: from hype to insight?" ReCALL vol. *24*(3), 2012, pp. 243–256.

[12] Csikszentmihalyi, M. "Creativity: Flow and the Psychology of Discovery and Invention," Harper Perennial, 1997.

[13] deHaan, J., Reed, W.M., and Kuwada, K. "The effect of interactivity with a music video game on second language vocabulary recall," Language Learning & Technology vol. 14(2), 2010, pp. 74–94.

[14] Dow, S., Fortuna, J., Schwartz, D., Altringer, B., Schwartz, D., and Klemmer, S. "Prototyping dynamics: sharing multiple designs improves exploration, group rapport, and results," Proceedings of the 2011 annual conference on Human factors in computing systems, (CHI2011), ACM, 2011, pp. 2807–2816.

[15] Egenfeldt-Nielsen, S. "Beyond Edutainment: Exploring the Educational Potential of Computer Games." PhD Dissertation, online http://www.learninginvideogames.com/research-and-papers/beyond-edutainment-a-dissertation-by-simon-egenfeldt-nielsen/ [last accessed December 2012], 2005.

[16] Ermi, L. and Mäyrä, F. "Player-Centred Game Design: Experiences in Using Scenario Study to Inform Mobile Game Design," Game Studies: The International Journal of Computer Game Research vol. 5(1), 2005.

[17] Frazer, A., Argles, D., and Wills, G. "Assessing The Usefulness Of Mini-games As Educational Resources," ALT-C 2007: Beyond Control, 2007.

[18] Gaver, B., Dunne, T., and Pacenti, E. "Design: Cultural probes," Interactions vol. 6(1), 1999, pp. 21–29.

[19] Gaver, B. and Martin, H. "Alternatives: exploring information appliances through conceptual design proposals," Proceedings of the SIGCHI conference on Human factors in computing systems (CHI2000), 2000, pp. 209–216.

[20] Gaver, W.W., Beaver, J., and Benford, S. "Ambiguity as a resource for design," Proceedings of the SIGCHI conference on Human factors in computing systems (CHI2003), ACM, 2003, pp. 233–240.

[21] Greenberg, B.S., Sherry, J., Lachlan, K., Lucas, K., and Holmstrom, A. "Orientations to Video Games Among Gender and Age Groups, "Simulation & Gaming vol. 41(2), 2010, pp. 238–259.

[22] Griffiths, M. "The therapeutic use of videogames in childhood and adolescence, "Clinical child psychology and psychiatry vol. 8(4), 2003, p.547.

[23] Hackos, J.A. and Redish, J.C. "User and Task Analysis for Interface Design, "John Wiley & Sons, Inc., 1998.

[24] Hartmann, T. and Klimmt, C. "Gender and Computer Games: Exploring Females' Dislikes," Journal of Computer-Mediated Communication vol. 11(4), 2006, pp. 910–931.

[25] Hubbard, P. "Evaluating Computer Games for Language Learning," Simulation & Gaming vol. 22(2), 1991, pp. 220 – 223.

[26] Hubbard, P. "Interactive Participatory Dramas for Language Learning," Simulation & Gaming vol. 33(2), 2002, pp. 210 – 216.

[27] ISO. "ISO 9241-210:2010 - Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems," http://www.iso.org/iso/catalogue_detail.htm?csnumber=52075 [last accessed September 2012], 2010.

[28] Johnson, W.L. "Serious Use of a Serious Game for Language Learning," Proceeding of the 2007 conference on Artificial Intelligence in Education: Building Technology Rich Learning Contexts That Work, IOS Press 2007, pp. 67–74.

[29] Kirriemuir, J. and McFarlane, A. "Literature review in games and learning," Futurelab, 2004.

[30] Klimmt, C., Hartmann, T., and Frey, A. "Effectance and control as determinants of video game enjoyment," Cyberpsychology & Behavior vol. 10(6), 2007, pp. 845–847.

[31] Klimmt, C., Rizzo, A., Vorderer, P., Koch, J., and Fischer, T. "Experimental Evidence for Suspense as Determinant of Video Game Enjoyment." Cyberpsychology & Behavior vol. 12(1), 2009, pp. 29–31.

[32] Klimmt, C., Schmid, H., and Orthmann, J. "Exploring the Enjoyment of Playing Browser Games." Cyberpsychology & Behavior vol. 12(2), 2009, pp. 231–234.

[33] Larian Studios and Die Keure. "Monkey Tales Games - Educational math games." http://www.monkeytalesgames.com [last accessed: September 2012], 2011.

[34] Laurel, B. and Lunenfeld, P. "Design Research: Methods and Perspectives," The MIT Press, 2003 .

[35] Lazzaro, N. "Why We Play Games: Four Keys to More Emotion Without Story," Game Developers Conference, 2004.

[36] Malone, T.W. and Lepper, M.R. "Making learning fun: A taxonomy of intrinsic motivations for learning," Aptitude, learning, and instruction vol. 3, 1987, pp. 223–253.

[37] Miller, M. and Hegelheimer, V. "The SIMs meet ESL. Incorporating authentic computer simulation games into the language classroom " Interactive Technology and Smart Education vol. 3(4), 2006, pp. 311–328.

[38] Pagulayan, R.J., Keeker, K., Wixon, D., Romero, R.L., and Fuller, T. "User-centered design in games," In J.A. Jacko and A. Sears, eds. The Human-Computer Interaction Handbook. Fundamentals, Evolving Technologies and Emerging Applications. L. Erlbaum Associates Inc., Hillsdale, NJ, USA, 2003, pp. 883–906.

[39] Papert, S. "Does Easy Do It? Children, Games, and Learning *"* Game Developer, 1998, pp. 87–88.

[40] Pruitt, J. and Grudin, J. "Personas: practice and theory". Proceedings of the 2003 conference on Designing for user experiences (DUX '03), ACM 2003, pp. 1–15.

[41] Purushotma, R., Thorne, S.L., and Wheatley, J. "10 Key Principles for Designing Video Games for Foreign Language Learning," 2008. http://knol.google.com/k/10-key-principles-for-designing-video-games-for-foreign-language-learning# [last accessed May 2011].

[42] Ranalli, J. "Learning English with The Sims: exploiting authentic computer simulation games for L2 learning," Computer Assisted Language Learnin, vol.21(5), 2008, pp. 441–455.

[43] Salen, K. and Zimmerman, E. "Rules of Play: Game Design Fundamentals," MIT Press, 2003.

[44] Sanders, E.B.N. "From user-centered to participatory design approaches," Design and the social sciences: making connections vol. 2, 2002, p. 1.

[45] Sanders, R.H. and Sanders, A.F. "History of an AI spy game: Spion," In Thirty years of computer assisted language instruction. CALICO, 1995, pp. 114–127.

[46] Schuler, D. and Namioka, A. "Ethnographic Field Methods and Their Relation to Design," In Participatory Design: Principles and Practices. Routledge, 1993.

[47] Serious Games Interactive. "Global Conflicts: Palestine," Gamers Gate, Manifesto Games & Macgamestore, 2007.

[48] Sherry, J.L., Lucas, K., Greenberg, B.S., and Lachlan, K. "Video game uses and gratifications as predictors of use and game preference," In Playing video games: Motives, responses, and consequences, Lawrence Erlbaum Associates, 2006, pp. 213–224.

[49] Sherry, P., Lucas, K., Greenberg, B., and Lachlan, K. "Playing video games: motives, responses, and consequences, "Routledge, 2006.

[50] Spongelab Interactive. "Genomics Digital Lab - History of biology," Spongelab Interactive, 2009.

[51] Sulmon, N., Derboven, J., Montero Perez, M., and Zaman, B. "Creativity as a process: a participatory design approach to gather mobile language learning user requirements," Proceedings of the IADIS international conference e-learning 2011, 2011, pp. 429–437.

[52] Sykes, J.M. "Learner requests in Spanish: Examining the potential of multiuser virtual environments for L2 pragmatic acquisition," In L. Lomicka and G. Lord, eds. The Next Generation: Social Networking and Online Collaboration in Foreign Language Learning. Computer Assisted Language Instruction Consortium, Durham, 2009.

[53] Thoring, K. and Müller, R.M. "Understanding the creative mechanisms of design thinking: an evolutionary approach, " Proceedings of the Second Conference on Creativity and Innovation in Design (DESIRE'11), ACM, 2011, pp. 137–147.

[54] United Nations World Food Programme. "Food Force: The First Humanitarian Video Game," World Food Programme, 2005.

[55] Utrecht School of the Arts, Monobanda, and Metagama. "GAME SEEDS" 2012. http://www.gameseeds.net/ [last accessed September 2012].

[56] Vanden Abeele, V., Geurts, L., Husson, J., Windey, F., Annema, J., Verstrate, M., and Desmet, S. "Designing Slow Fun! Physical Therapy Games to Remedy the Negative Consequences of Spasticity," Proceedings of the 3rd International Conference on Fun and Games (FnG 2010), ACM Press, 2010.

[57] Vanden Abeele, V. and De Schutter, B. "Designing intergenerational play via Enactive Interaction," Competition and Acceleration. Journal of Personal and Ubiquitous Computing: Special Issue on Design for Social Interaction through Physical Pla*y*, 2009.

[58] Vanden Abeele, V., Schutter, B., Geurts, L., Desmet, S., Wauters, J., Husson, J., Van Audenaeren, L., Broeckhoven, F., Annema, J.,and Geerts, D. "P-III: A Player-Centered, Iterative, Interdisciplinary and Integrated Framework for Serious Game Design and Development," In S. Wannemacker, S. Vandercruysse and G. Clarebout, eds., Serious Games: The Challenge. Springer Berlin Heidelberg, 2012, pp. 82–86.

[59] Vorderer, P. and Bryant, J. "Playing Video Games: Motives, Responses, and Consequences," Lawrence Erlbaum Associates, 2006.

[60] Winograd, T. and Kuhn, S. "Participatory Design,"In Bringing Design to Software. Addison-Wesley, 1996.

[61] Yee, N. "Motivations for Play in Online Games." CyberPsychology & Behavior vol. 9(6), 2006, pp. 772–775.