Spatial Choices in an Educational Geogame

Dominik Kremer, Christoph Schlieder
Chair of Computing in the Cultural Sciences
University of Bamberg, Germany
Email: dominik.kremer@uni.bamberg.de
christoph.schlieder@uni.bamberg.de

Barbara Feulner, Ulrike Ohl
Chair of Geography Education
University of Augsburg, Germany
Email: barbara.feulner@geo.uni-augsburg.de
ulrike.ohl@geo.uni-augsburg.de

***Abstract*—Geogames are location-based games played in outdoor environments. Many use a time out mechanism to balance game play. Little is known on how this affects player motivation in learning experiences. We report evidence from an explorative empirical study which indicates that the perceived choice of a player has impact on the enjoyment of the learning experience. We identify the spatial choices of the players from their GPS tracks and describe game design decisions that affect the number of spatial choices available to a player.**

***Index Terms*—location-based games; game-based learning; Geogames; case studies and user studies; game design**

I. Introduction

Geogames are location-based games where the players use GPS smartphones or tablets to interact with the game and to communicate among each other [3]. Although these games are fundamentally spatial games, they are much better characterized as being locomotion games. A critical design issue concerns timing: understanding race conditions, understanding how important the speed of locomotion is to a winning strategy at a particular moment of the game, understanding rubberbanding mechanisms, i.e. ways to keep the outcome of the game open as long as possible [6].

A successful way to address timing issues in Geogames consists in introducing some kind of time out mechanism in the game to give slower players the opportunity to catch up. In game-based learning, the breaks provide an opportunity to engage in learning activities, e.g. a quest. Generally, such activities blend with the gaming experience and are perceived by the players as playing time instead of idle time. Little is known, however, on how this temporal balancing affects player motivation and which choices in the game design could improve the motivation.

This article reports first findings based on an explorative empirical study of player motivation and spatial choices in an educational Geogame. It is based on using the CityPoker Geogame. Very briefly, it is a game played by two teams that start with a given poker hand and move around in an urban environment to find cards hidden in caches in order to improve their poker hand. In our geography learning scenario, finding the caches involved correctly solving geographic problems. We focus on implications for game design and will not be able to discuss how learning, for instance, the improvement of spatial orientation skills, takes place in all phases of the game. The main contributions are: (1) we present an explorative study which indicates that the perceived choice of a player has an impact on enjoying the game-based learning experience; (2) based on an analysis of the players GPS tracks we identify the spatial choices available to a player; (3) we discuss implications for design, that is, game design decisions affecting the spatial choices.

The article is structured as follows: section II reviews related work on game design and player motivation. We report findings from our empirical study with CityPoker (section III) and analyze the GPS tracks of the players (section IV). Finally, we conclude with discussing implications for the design of location-based games (section V).

II. Timing and Choice in Geogames

Geogames have attracted considerable research interest – a ludography from 2007 already listed more than 100 games [7]. Temporal balancing is a design issue for most of them. Some mechanism is needed to compensate for the differences in locomotion speed which always exist between players. Otherwise a trivial winning strategy dominates most Geogames: the fastest player wins. Several mechanisms are available for the temporal balancing of games in general [1]. Much less is known about timing in Geogames [3]. For some Geogames it has been possible to compute a uniform time out interval which depends on the maximum speed in locomotion difference that one wants to control, the size of the geographic game board as well as a number of other parameters [6]. Players will typically not notice the time out. They are assigned a learning task which would take the average player just this amount of time to complete. The players are not forced to wait if they complete the task earlier.

Motivation is known to be crucial for successful learning processes. A recent survey describes subjective and objective methods for assessing the motivation of learners/players in game-based learning [4]. The Intrinsic Motivation Inventory (IMI) based on the Self-determination Theory of Ryan and Deci [5] is frequently adopted by game researchers. One central statement of the theory is that in an educational context intrinsic motivation results in a more effective way of learning. We make use of the IMI subscale described by [8].

To our knowledge the issue of spatial choices has not been systematically explored in the literature on Geogame design. There is, however, previous research that applies spatial analysis to Geogames for the purpose of visualizing player behavior in a time-geographic framework [2].

For the game-based learning experience, we used CityPoker, a Geogame we created which provides ample time for incorporating educational content by the nature of its time out mechanism. The game is played on GPS smartphones. Two teams compete to improve their Poker hands by searching for suitable (physical) cards hidden in the urban environment. Without going into the details of the game mechanics, it is worth noting that the search process itself acts as the time out mechanism. Search can be speeded-up by the players if they are able to come up with the correct answers to the educational quests. All quests are location-based, that is, the quests are solved when the participants are at the place to which they relate.

III. Empirical Findings on Perceived Choice

The study was conducted with learning material from geography education created for on-site learning in a former textile district of Augsburg, Germany. 7th grade students (age group 13 to 14) from different schools of the city participated as learners/players (Fig. 1c and 1d). Learning objectives were defined to start from the geographical leading question of how the decline of the textile production affected the structure and usage of the area (Fig. 1a and 1b). The objectives included the acquisition of cognitive knowledge as well as the practicing of geographical work techniques such as the analysis of graphs or the interpretation and comparison of maps. Location-based educational content was created which referred to 10 places (points of geographic interest) of the textile district. This content was developed by students from the geography education program of the University of Augsburg.

Fig. 1. Learning to read a changing urban design: (a) industrial brownfield (b) new service businesses, (c) Geogame learning, (d) field trip learning

In lessons preceding the actual game event, the participants acquired knowledge about the period of the industrialization and the important role Augsburg played in manufacturing textiles. They also worked out reasons for the decline of textile production at this site and were introduced to the geographical leading question. In addition to that, the procedure of the actual game-event, the rules of the game and the functionality of the game were talked over with the students.

The motivation of the learners/players was observed in a comparative study with 28 7th grade students split into two groups with 14 players each. Group *A* first went on an excursion to 5 of the 10 points of interest while group *B* visited in their excursion the remaining 5 points. In the subsequent game phase, each group played on the 5 points of interest it had not seen, divided in two opposing teams consisting of 7 players. The excursion through the textile district was conducted by geography education students from the University of Augsburg. After the excursion and the game each participant had visited all 5 points of interest of the excursion and – depending on the gameplay – between 3 and 4 points of interest of the game.

The intrinsic motivation of the students participating in the excursion and the CityPoker game was assessed with a subscale of the Intrinsic Motivation Inventory (IMI) [5]. We used the KIM subscale whose retest reliability and validity have been shown by [8]. Within this scale 12 items reflect the four factors ‘interest/enjoyment’, ‘perceived competence’, ‘perceived choice’ and ‘pressure/tension’. They were answered by the participants on a 5-point Likert scale ranging from 4 (I totally agree!) to 0 (I do not agree at all). Each factor is covered by three items. KIM has been published as a German language questionnaire which makes reference to the specific learning scenario used in the reliability and validity studies of the scale [8]. However, the items can easily be rephrased for a game playing context and then translated into English, for instance, as:

- “The excursion/CityPoker game was fun to do.” (v1, interest/enjoyment)
- “I am satisfied with my performance at the excursion/ CityPoker game.” (v4, perceived competence)
- “I could control my activity in the excursion/ CityPoker game.” (v7, perceived choice)
- “I felt pressured in the excursion/CityPoker game.” (v10, pressure/tension)

The average scores for the four factors of the KIM short scale do not show significant differences between the excursion and the Geogame (Fig. 2). With both learning scenarios, interest/enjoyment and perceived competence are high and pressure/tension is very low, whereas the perceived choice is on an average level. Only item v8 (perceived choice: In the excursion/CityPoker game, I was able to choose how to do it.) and item v11 (pressure/tension: In the excursion/CityPoker game, I felt tense.) differ significantly.

We see this as a first indication that the temporal overhead (time spent on searching tasks in the game) has no or at least not a sizable negative effect on learners/player motivation.

The authors of the KIM short scale [8] have already noted that despite a good separation by varimax rotation the item v12 (tension: “I was worried, whether I would manage the activity”) is not stable. It can load (with a negative value) on enjoyment as well as (with a positive value) on tension. From the perspective of our research question this has the benefit

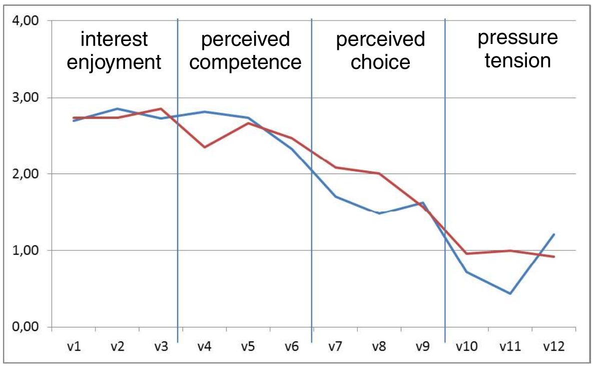

Fig. 2. Average scores (n=28) on the KIM short scale for the excursion (blue) and CityPoker (red): interest (v1-v3), perceived competence (v4-v6), perceived choice (v7-v9), pressure (v10-v12).

that the varimax rotation also allows for the analysis of other contributing variables in the data sample.

A stepwise regression taking v4-v12 as independent items loading on the factor 'enjoyment' revealed an interesting effect (cf. Table I). Whereas a model formed of items v10 (tension with a negative coefficient) and v7 (perceived choice) helped explain enjoyment during the excursion, enjoying CityPoker is explained by v4 (perceived compentence) and v7 (perceived choice).

TABLE I
PLAYER MOTIVATION

	item	*Coefficient*	*p-Value*
Excursion	perceived choice (v7)	0.530	< 0.1
	pressure/tension (v10)	-0.331	
CityPoker	perceived competence (v4)	0.271	< 0.1
	perceived choice (v7)	0.622	

This can be interpreted as an effect of perceived choice in both cases. More specifically, excursions are perceived as enjoyment, if the students do not feel tense, whereas CityPoker is perceived as enjoyment, if the students are satisfied with their own competence. In addition, open feedback from the students revealed that it was the learning situation itself that was perceived as positive, not the playing around with a smartphone app.

Additional written feedback given by the students showed that acquiring knowledge during CityPoker was perceived very positively by them. Students stated for example that they had the feeling that they could remember the content better or that they enjoyed learning.

IV. QUALITATIVE ANALYSIS OF SPATIAL DECISIONS

For the designer of a Geogame it is interesting to learn that perceived choice seems to positively affect the intrinsic motivation of the players. In CityPoker like in most other Geogames, many of the choices are spatial: deciding which point of interest to visit next, deciding where to start searching, and so on. During the game, the tracks of the two opposing teams were recorded by logging a GPS position every five seconds. These tracks provide the game designer with a valuable data source for understanding spatial choices.

In a Geogame which is played on a street network, players have to choose between different turn options at every crossing. More complex behavioral patterns arise from chaining two or more of such choices. A qualitative geospatial analysis of the CityPoker games reveals two specific behavioral patterns, navigation and search. The identification of the patterns is based on the spatial properties of the GPS tracks as well as on the temporal context in which they occur in the game play.

Navigation patterns include the efficient zigzagging along a shortest path in the street network as well as the trial and error behavior illustrated in Fig. 3a and 3b. In some cases, the players exhibited difficulties in aligning the display map with the environment and made trial movements before finding the correct heading (Fig. 3a). In other cases, they simply had to turn back to correct an erroneous navigation decision (Fig. 3b). With respect to the excursion the contrast could hardly be more distinct. The participants of the excursion just followed the teacher through the street network without having to take any navigation decisions by themselves.

The *search patterns* (Fig. 3c and 3d) correspond to spatial behavior that is caused by the game mechanics. CityPoker requires the players to search for Poker cards hidden in the environment and specifies bounded regions where the search should take place. Players either engaged into a local search for a cache (Fig. 3c) or they realized that they searched at the wrong location and turned back (Fig. 3d). Obviously, similar spatial decisions were absent in the excursion which did not include any search-based game elements.

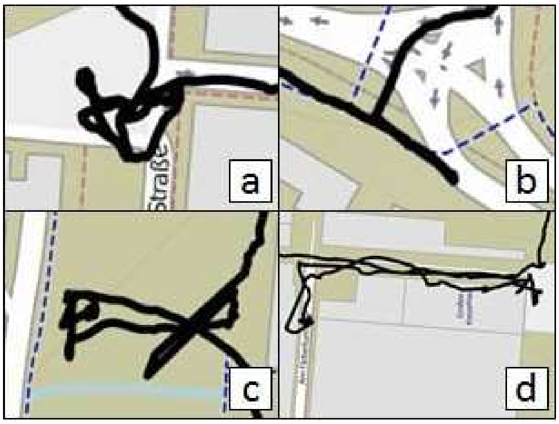

Fig. 3. Behavioral patterns illustrating spatial choices: (a) navigation pattern, orientation (b) navigation pattern, walk back (c) search pattern, local search (d) search pattern, walk back

The two types of behavioral patterns differ in the degree to which they are connected with the game play. Navigation is not necessarily part of CityPoker and pedestrian navigation support could easily be added to the game software as it has been done for other Geogames. This would eliminate backtracking patterns (Fig. 3b). Technical solutions for avoiding orientation patterns resulting from misaligning map and environment (Fig. 3a) are also known but involve further sensors like a magnetic compass. However, it is more questionable whether the game design should aim at completely eliminating navigation "errors" since acquiring navigation skills is often considered an important part of the learning objectives. While the game designer may choose to reduce the navigation choices of a Geogame by providing technical assistance, it is difficult to increase the navigation choices other than by relocating the game to a more complex street network.

Since search constitutes an essential game element in CityPoker, the patterns of local and global search are player behavior that the game mechanics aims at producing (Fig. 3c and 3d). Searching an item in the environment necessarily involves the possibility of looking for it at the wrong places. Eliminating these patterns is of no interest to the designer. There are, however, degrees of freedom in designing the difficulty of the search tasks. In CityPoker a simple but effective mechanism is used for that purpose: quests with results that correspond to multiple spatial choices. In the most basic version, a question is provided with several answer options, say, *a*, *b*, *c*, and *d*. Each answer option corresponds to a bounded search region of a standard size. Without knowing the answer, all four regions must be searched. Narrowing down the answers to either b or c cuts search time in half on average. Coming up with the correct answer b minimizes search time.

From the perspective of game design, the freedom of spatial choices is tied to the risk of taking the wrong decisions. This comes at a price which can be specified in the case of CityPoker. Correcting errors cost the players the physical effort of walking back. It is remarkable, that this price seems not too high for most players to prevent the freedom of choice having a positive effect on enjoyment.

V. Conclusions and Outlook

The Geogame design issue of temporal balancing is generally addressed by some time out mechanism which prevents the players from reaching game positions too quickly. In CityPoker, the time out is implemented by the search processes for cards in the environment that the players need to engage in. As this mechanism could have been perceived as temporal overhead (waste of time) in game-based learning, we were interested in knowing more about player motivation in this Geogame.

In a geography learning scenario, 7th grade students were observed while playing CityPoker on 5 points of geographic interest as well as following an excursion on other 5 points. Using the IMI for assessing intrinsic motivation, we found no significant difference in the motivational factors between the game and the excursion. We see this as a first indication that the temporal overhead produced by the game mechanics has no or at least not a sizable impact on learners/player motivation.

Further analysis that looked at other factors as independent items explaining interest/enjoyment revealed a noteworthy difference between the game and the excursion. Whereas enjoyment is a function of perceived choice and lack of tension in the excursion, it is a function of perceived choice and perceived competence in the game. In other words, perceived choice affects enjoyment in both cases whereas tension – maybe induced by the presence of a teacher in the excursion – seems to be no or at least a much lesser concern in the game.

Finding an effect of perceived choice on enjoyment led us to study the designer's options for influencing the spatial choices in the game. An analysis of the players' GPS tracks showed that in CityPoker there are at least two kinds of choices to consider, those relating to navigation and those relating to search. It turns out that although navigation choices can be reduced, it is difficult to increase them by design. In contrast, the designer can influence the search choices in both ways by increasing or decreasing the complexity of the search task.

In conclusion, it seems that spatial choice is a critical, and maybe underrated, design parameter for Geogames. This does not imply an automatism. More choice does not necessarily mean more enjoyment. We are still at the very beginning of understanding of how exactly choice affects learners/players enjoyment. Nevertheless, we learn from our analysis that the designers of Geogames should take into account that there are different types of spatial choices.

This raises a number of follow-up questions for future research. The first question is how the spatial player decisions relate to non-spatial decisions that might also affect perceived choice. Next, it would be interesting to know whether the two types of spatial choices, navigation and search, affect the perceived choice differently. These questions are not only relevant for game design but also important for a better understanding of the learning processes.

Acknowledgment

Claus Carbon provided helpful comments on the statistical analysis of the data. We thank our student assistants from Bamberg who implemented the Geogame and all the students from Augsburg who staged it. Part of the development was funded by ESRI Inc. within the "Geogames and playful Geodesign project".

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