Does Team Size Matter in Mobile Learning?

Gerhard Schwabe, Christoph Göth, Dirk Frohberg
University of Zurich, Department of Informatics
{schwabe, goeth, frohberg}@ifi.unizh.ch

Abstract

Most mobile learning applications support individual users, although experience with similar conventional learning games indicates that teams may be more appropriate. This paper reports on tests of the MobileGame to see whether individual users, teams of two, teams of three or teams of four are more successful. The test was conducted with over 100 natural users. The significantly increased activity level and team-building show that a preference for teams of two rather than individual players would be justified. There is little significant evidence to prefer teams of two to teams of three. However, the data shows that teams of four are suboptimal: This team size decreases fun and immersion as well as (maybe) learning. There is no evidence that these negative effects are balanced by improved team-building. The relatively high success of teams of two leads to a need for more research on dyadic users not only for mobile learning games, but also for other areas such as tourism, health, museum visitors, and entertainment.

1. Introduction

While preparing the evaluation of our mobile learning game MobileGame we were discussing the optimal team size for running the game. Based on our experience with similar conventional games and previous tests of a mobile learning game [17] we quickly came to the conclusion that the best solution would be to have teams of two players sharing one PDA. Then it struck us that this solution is in obvious contrast to all other tests of mobile learning or mobile games we know of. We, therefore, decided to test whether our assumption was correct and admitted a limited number of individuals, teams of two, three, and four to our test. This paper will report on the results of those aspects of the evaluation. In the next section, we will briefly introduce the concept of mobile learning and mobile games and discuss related work with a particular focus on team size. The third section briefly explains the software and the envisioned usage scenario. The fourth section explains the experimental design and introduces five hypotheses on the effects of team size on the game experience and the game outcome. The fifth section explains the data collection. The sixth section presents the results and the final section discusses implications of these results.

2. Literature Review

2.1 Mobile Learning and Mobile Games

Mobile learning has been defined as "any sort of learning that happens when the learner is not on a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies" [11]. Typical devices for mobile learning include PDAs (Personal Digital Assistant), tablet PCs, Smart-phones and even cell-phones. There have been efforts to support traditional behaviouristic learning with mobile technologies, e.g. by broadcasting lectures to cell-phones or by providing train travellers with learning material on a PDA [9]. The main benefit of this approach is convenience (particularly, the opportunity to learn in any place at any time) rather than improved learning. Significant learning benefits have been claimed from supporting situated learning, e.g. in a museum (e.g. the London Tate Gallery), botanic garden [6], or children's outdoor explorations [23]. Often, this kind of learning happens outside formal learning contexts.

There are already a few mobile systems that integrate playing and learning, such as the Cooties Game or Geney [13] or Savannah [5]. They focus on role-play or simulation. Prototypes and commercial products of location-based games in a real life environment, like CYSMN [1], Pirates [2] or Mogi [8], show that people like to play with the new options, but these games focus purely on entertainment.

Mobile learning projects report three main benefits of mobile learning as opposed to desktop computer supported learning:

1) context-dependent services: the context does not only include the location, but also the learner's profile, his social network, other users within the same system, the time etc. [19].

2) continuous and immediate access to a lightweight mobile device supporting learning: this immediacy

Proceedings of the International Conference on Mobile Business (ICMB'05)
0-7695-2367-6/05 $20.00 © 2005 **IEEE**

does not only enhance information access and ease of use [22], but also allows for more choices of the degree of synchronicity for a given activity [16] and immediate task closure [21] (writing down an idea, coordinating an activity). The success of SMS in Europe shows that users go through some effort in order to achieve immediate task closure.

3) Mobile learning can be a rich experience [17], particularly if it allows participants to immerse in a mixed reality environment. This characteristic is of increasing importance as Western countries move towards an "experience economy" [12].

2.2 Team Size in Mobile Learning and Mobile Games

For the purpose of this paper, we have a very restrictive definition of a team: A team represents two or more players who play together as one game entity, competing against (or cooperating with) other game entities. The set of all players/game entities participating in a game is not regarded as a team. They rather participate in the same "game run". This definition makes sense if one wants to study the effects of the very intense collaboration of actors happening when players are tied together in their decisions and actions like a pilot and a co-pilot in an airplane.

Research in Group Support Systems [4] demonstrates that groups can be more efficient in brainstorming than individuals. Also in the area of CSCL there are investigations of the effects of group size. Stahl [20] argues that groups "build group knowledge and shared meaning that exceeds the knowledge of the group's individual members."

Extensive literature reveals that there is no prior knowledge on the influence of team size on mobile learning games. We started with four recent state of the art papers on mobile learning and mobile learning games [18] [13] [10] and added all related systems we know of. We selected all papers describing usage experiences with a system supporting a mobile learning or game experience within a limited time-frame and in interaction with other persons. All in all 30 systems were analyzed.

All systems described in the survey (except for our MobileGame) are based on the notion that each player is using his/her individual device and plays on his/her own[1]. The (reported) success of these systems may be due to their limited complexity. Typically, they are only complex on one or two dimensions. Car navigation systems show how difficult it is to support individuals in a mobile context without causing an information overload. Games that involve complex physical navigation, complex social interaction, and a complex task at the same time may lead to a very high cognitive load as players may have to deal simultaneously with information coming from different channels. This cognitive load may hamper the performance of an individual. On the other hand, such complex games provide a very rich experience that may lead to increased fun and intensive learning. Creating small teams playing together may be an appropriate social solution to deal with cognitive overload. Such teams may also have additional motivational and learning benefits for the participants. The next section will briefly introduce the scenario of such a complex game and the MobileGame software implementing the scenario.

3. Scenario and Software

The MobileGame is used to support the orientation days at a university. The traditional orientation rally is electronically supplemented with handheld devices. The orientation rally is a fun event aimed at familiarizing the students with the university and its surroundings. Therefore, the rally will lead all participants through an area with several tasks to carry out at certain spots. The students play individually or in small teams (1-4 persons) against each other or against other teams[2]. Each individual /team receives a handheld computer.

During the orientation rally, each team gets different tasks referring to significant places, people and events (explained below). The handheld device shows the current position of the team on the digital map of the university. When the team enters a building, the outdoor map switches to an indoor map of the building the team just entered. The whole rally is structured as a cooperative and competitive game. Competition is based on hunting rules: Each team tries to catch another team and, equally, is hunted by a third team[3]. The handheld device shows each team where its hunter and its prey are located. Cooperation rules force team members to meet members from other teams as well as teachers and to exchange information with them - again they are supported with location based information on their displays. The tasks given to them provide them with basic information on university live. There are the following types of tasks:

[1] Anecdotal evidence for the benefit of sharing one device has so far only been reported from computer supported workshop, e.g. in [13].

[2] In order to simplify the text, this scenario assumes that a there is a team of players.

[3] The didactic reason for hunting rules is to keep the groups moving. Of course, there need to be hunting free areas and times, e.g. during lectures/seminars.

- Significant place tasks: The students have to find important places, such as the library, the cafeteria or the laboratories. At each location, they have to perform a typical task (find a book, have lunch, etc.). The specific tasks are context-dependent (they depend not only on the location, but also on the time of the day or they build on the activity of some previous team). The task execution is supported by the handheld device (e.g. serving as a front-end to the library information system or providing them with needed information).
- Significant people tasks: The students have to find important people of the university and have to interview them on their activities (the president, the study coordinator, the caretaker…).These people either participate in the game or are played by elder students). If those people are typically mobile they can be located by a mobile device.
- Significant event tasks: The significant events can be scheduled or come as surprise. Scheduled events include introductory lectures and courses. Here, tasks relate to the organization of studies (e.g. set up a course schedule or how to find important information) and some initial content. Unscheduled events include "spontaneous" welcome parties by student groups, but also the signup of each team member to important university services (e.g. computer account, library card).

Each task requires the team to answer one or two simple questions displayed on the handheld device. For example, one task might be to find the cafeteria. There they get the question "What is the price of an apple pie?". They won't get the next task until the correct answer is given.

4. Hypotheses

In a previous evaluation of the a mobile game [17], the motivational aspects of the game turned out to be highly important. Therefore, it is interesting to check whether the size of the team has an effect on fun. This leads to hypothesis H1.

Hypothesis H1: Players in teams of two have the most fun

H1.1 Players in teams of two have more fun than individual players

H1.2 Players in teams of two have more fun than players in teams of three

H1.3 Players in teams of two have more fun than players in teams of four

In conventional orientation games, many individuals have trouble orienting with a map and a sheet of paper with the tasks. A discussion with a partner helps to clarify ones own thoughts and their combined knowledge may lead to better solutions. At least it leads to a feeling of more security and thus increases fun. Navigating and solving tasks in an unknown mixed reality environment may easily lead to an information overload that can be overcome by distributing the load between two persons. Furthermore, according to an old saying a pleasant experience shared is pleasure doubled. Thus, it is plausible that players in teams of two have more fun than individuals. If the team size increases beyond two more people share an experience, leading to even more fun. However, this effect is countered by increasing coordination problems. If there is no clear separation of tasks (which is not possible in the MobileGame) the average player is up to twice as long in a receptive mode (observing or listening to what others do) than in an active mode, which reduces the fun. This leads us to the hypothesis that fun peaks with a team size of two.

In the analysis of the prior trials [17], the authors speculated that the players' immersion into a mixed reality environment was to a large extent responsible for the fun. This leads to hypothesis H2:

Hypothesis H2: Players in teams of two have the best immersion experience

H2.1 Players in teams of two experience more immersion than individual players

H2.2 Players in teams of two experience more immersion than players in teams of three

H2.3 Players in teams of two experience more immersion than players in teams of four

The larger the team size becomes the more social activities dominate and the less visible is the technology and the game. This influence may be more than balanced for teams of two by their increased capabilities and activity level, but it becomes dominant in larger teams. The activity level of more than two players becomes too low to engage them. This effect will be evaluated directly in hypothesis H3. Hypothesis H3 focuses only on goal oriented activities. Goal orientation will be measured by the success of an activity.

Hypothesis H3: Players in teams of two have the highest successful activity level

H3.1 Players in teams of two have a higher successful activity level than individual players

H3.2 Players in teams of two have a higher successful activity level than players in teams of three

H3.3 Players in teams of two have a higher successful activity level than players in teams of four

The major difference between mobile learning games and other mobile games is its purpose: While other mobile games are purely for entertainment mobile learning games strive to use the fun created by the game to advance learning. Therefore, a major objective of the final Mobilearn evaluation was to establish the effect of the MobileGame on the learning outcome. In this paper, it is interesting to see which team size leads to the best learning outcome. One indirect indicator is the number of activities successfully completed as discussed above. But one can also measure learning directly.

Hypothesis H4: Players in teams of two learn most

H4.1 Players in teams of two learn more than individual players

H4.2 Players in teams of two learn more than players in teams of three

H4.3 Players in teams of two learn more than players in teams of four

Best learning outcome for teams of two is a direct result of the higher activity level and fun and furthermore of the possibility to externalize and exchange knowledge. In larger teams, this effect is offset by the increasing difficulties in coordination.

McGrath [7] proposes that the outcome of team work cannot only be reduced to its production function, but group-wellbeing is equally important. It is also well-established that creating a team from individuals is of great importance for later functioning of both working and learning teams [15]. New university students are in a situation where they depend on creating a new network to support their social and learning activities. In this paper, it is interesting to find out how team size contributes to learning outcome.

Hypothesis H5: The larger the team the better is the team-building experience

H5.1: Players in teams of two have a better team-building experience than individuals

H5.2: Players in teams of three have a better team-building experience than players in teams of two

H5.3: Players in teams of four have a better team-building experience than players in teams of three

Even the individuals operate in a social context as they play against other individuals and teams. But they interact only infrequently with them – some of them are even catchers whom they have to avoid. The team-building experience can, therefore, only result from interactions after the game has ended. Therefore, we propose that team-building will be rather low for individual players. With an increasing number of participants in a team each member gets to know more others. As people get to know others mainly by observing rather than by acting, the team-building experience improves with team size – as long as there is sufficient time to get to know others. This limit is not reached by a game with a team size of four.

The variables are measured as follows:

1) Team size: The conductors of the experiment take note of the team sizes at the beginning of each run and check again after the experiment.

2) The successful activity level is the numbers of tasks a team is able to solve during one run. Note that this variable is measured at the team level and not at the member level.

3) Learning is measured objectively and subjectively. The objective measurement compares the knowledge of a pre-test with the knowledge of a post-test. The subjective measurement captures the subjective feeling of how much each participant has learned with a five-point Likert scale. The question was "How much did you learn by playing the game?". The possible answers ranged from 1= very little to 5=very much.

4) Fun, immersion and team-building is also measured with the five-point Likert scales. The questions were: "How much fun was it to play the game?" to measure fun, " How much would an interruption of 10 minutes of the game have disturbed you?" to measure immersion and "How helpful was the game to stimulate team-building in your tutorial group?" to measure team-building. The possible answers ranged for all questions from 1= very little to 5=very much.

While it may be possible to measure the motivational aspects of a mobile learning game with any volunteering participants, effects on learning and team-building can only be measured with real participants, i.e. students who are new to the campus. The experiment was, therefore, designed to include as many new students as possible and thus trade off external validity for control over all variables. As there were only 90 minutes available for all parts of the experiment (classes started afterwards) only a limited post-questionnaire could be applied directly after the experiment. An extended second questionnaire was answered at home. Only the data for immersion is based on this second questionnaire.

5. Data collection

At the beginning of the winter term 2004, all 149 students of an introductory course to computer science were asked to participate in a game that introduced them to the Irchel campus of the University of Zurich. The majority of the students (58%) were computer scientists, the rest were mainly enrolled in natural sciences. The average age of the participants was 23 years. We offered 12 possible dates to participate in the game. Two of the dates were reserved for control teams (which are of no relevance for this paper).

Before each game run started, the students were given a pre-questionnaire with questions to their personal data and six knowledge questions about the campus. Afterwards, there was a short training session and then the game started. Each game lasted approximately

45 to 50 minutes. In this time, the students had the task to navigate to significant campus locations and to answer as many of 12 location-specific questions as possible. While doing so, they could catch other teams (and gain points) and communicate with other teams. The questions were distributed in random order. At the end of each game, each player was given a first post-questionnaire. The first post-questionnaire contained questions about their general impression and the six knowledge questions from the pre-questionnaire. The participants were also asked to fill in an extended second post-questionnaire at home as soon as possible and return it one week later. The extended post-questionnaire contained more detailed questions on the participants' experience and their evaluation of the software features.

As the test had to fit into the schedule of the participants and the study beginners were quite disorganized we had limited control over the number of participants on each date. The number of teams and the size of each team depended on the number of participants showing up on each date. There was a maximum of 18 persons participating in each game run and a minimum of 5 persons. In each game, there was a maximum of 9 teams and a minimum of 3 teams. There were individuals with one PDA and teams of two, three, four and five sharing one device.

Due to technical problems in the server, log data is missing for some teams. We also excluded one team from all evaluations (team level and individual level) who had started with two persons and only one person came back. All other participants handed in a short post-questionnaire filled in directly after the experiment. The majority of the participants also handed in the second post-questionnaire – some of them after reminders.

The missing log data reduces the number of available data sets on teams with four participants to three and the number of teams with three participants to four, too small a number to do statistical analysis on a team level. As we still have the questionnaire data from their participants, teams of three and four are included in the analysis on the individual level. As there was only one team with five persons we did not include them into our statistical analysis (team level and individual level).

6. Results

The results are presented in the order of the hypotheses.

Fun: Team size has a significant influence on the fun a member experiences during the game (ANOVA: sig.: 0,006; < 0,01). ANOVA requires a similarity of variances and can be problematic with Likert scales. The Levene test of homogeneity of variance shows that similarity of variances has to be rejected on the 5% significance level (but not on the 1% significance level). Therefore, the results were retested with the Kruskal-Wallis-H-Test (which is appropriate for inhomogeneous variances and Likert scales, but is a weaker test). It again reported significance on a level below 1% (asymp. sig. =0,006). Tukey HSD shows that the structural differences are between teams of size two and larger teams. The individuals reported about the same fun level (3,56) as members of the teams of two (3,66). So hypothesis H1.1 does not find support in the data. However, the fun in teams of three (2,93) and in teams of four (2,90) was lower. This difference is significant on the 5% level for the comparison between members in teams of two and members in teams of four (sig. = 0,017) and significant on the 10% level for the comparison between teams of two and teams of three (sig. = 0,057). Thus, there is strong support for hypothesis H1.3 and weak support for hypothesis H1.2.

Table 1: Results on fun

Size	N	Mean	Std. Dev	Tukey HSD		
1	9	3,56	0,88	2	3	4
				,992	,450	,359
2	70	3,66	0,93	1	3	4
				,992	,057	,017
3	15	2,93	0,70	1	2	4
				,450	,057	,000
4	20	2,90	1,37	1	2	3
				,359	,017	,000
Levene Test		Anova Significance		Kruskal-Wallis-H Significance		
0,017		0,006		0,006		

Size = Team size; N = Number of persons; Mean = Mean value on a scale from 1 = very little to 5 = very much

Immersion: The team size has a significant influence on the immersion a player experiences during the game (ANOVA: sig.: 0,014; < 0,05). As the Levene test rejects homogeneity of variance on the 1% level (sig. = 0,008), the Kruskal-Wallis-H-Test was applied. It supports significance on the 5% percent level (asymp. sig. = 0,013). Tukey HSD shows that the structural differences are between teams of size two and teams of size four. Individuals reported a mean immersion experience of 2,83, players in teams of two reported an immersion experience of 3,3, players in teams of three a mean of 2,93 and players in teams of four reported 2,17. Tukey HSD shows that only the difference between teams of two and teams of four is significant on a 5 % level (sig.: 0,007). The non-significance of the other results can be explained by their low sample size. Thus, hypothesis H2.3 is supported, H2.1 and H2.2 are not supported, but should be reevaluated with a larger sample.

Table 2: Results on immersion

Size	N	Mean	Std. Dev	Tukey HSD		
1	6	2,83	0,98	2	3	4
				,805	,999	,718
2	63	3,3	1,93	1	3	4
				,805	,704	,007
3	15	2,93	1,58	1	2	4
				,999	,704	,365
4	18	2,17	0,99	1	2	3
				,718	,007	,365
Levene Test		Anova Significance		Kruskal-Wallis-H Significance		
0,008		0,014		0,013		

Size = Team size; N = Number of persons; Mean = Mean value on a scale from 1 = very little to 5 = very much

Activity Level: While all other hypothesis have been tested on an individual level, this hypothesis is tested on a team level as teams successfully finished tasks as a whole entity. Only for individual players and teams of two the data set is sufficiently large for analysis. Thus, the test of hypotheses H3.2 and H3.3 has to be postponed. The mean number of successfully finished tasks is 2,77 for individuals and 4,41 for teams of two. Levene test rejects homogeneity of variances on a 5 % level (sig. = 0,048). The one-sided T-test for unequal variances shows that similarity of variances has to be rejected on a 5% level (sig. = 0,011)[4]. Thus H3.1 is supported by the data.

Learning: The data provides mostly insignificant and contradictory evidence on the learning effect. While the subjective learning decreases with team-size (individuals: 3, two: 2,76, three: 2,73, four: 2,1) the tested (=objective) learning increases (individuals: 1,92, two:2,11, three: 2,17, four: 2,7). However, the difference in tested learning is clearly not significant (ANOVA: 0,67). The learning effect is significant for subjective learning (ANOVA: 0,041, Levene: 0,390, Kruskal-Wallis-H: 0,024). Here, teams of size two report a significantly higher learning than teams of size four. Thus, hypothesis 4.3 is supported by the subjective learning data only. The other two hypotheses do not find support in the data.

Team-Building: The team size has a significant influence on team-building (ANOVA < 0,001). As Levene test rejects homogeneity of variance on the 5% level (sig. = 0,029), the Kruskal-Wallis-H-Test was applied. It supports significance on the 1% percent level (asymp. sig. < 0,001). However, Tukey HSD shows that the important differences are between individuals and teams of two: While individuals report a mean team-building experience of 1,44, members in teams of two report 3,2. Members of teams of three (mean = 3,47) and members of four (mean = 3,05) report only insignificant differences. Thus, hypothesis H5.1 is supported by the data and hypotheses H5.2 and H5.3 do not find support in the data.

Table 3: Results on learning

Size	N	Mean		Std. Dev	
		sub	obj	sub	obj
1	9	3,00	1,77	0,87	1,92
2	70	2,76	2,20	0,92	2,11
3	15	2,73	2,20	0,79	2,17
4	20	2,10	2,7	1,25	2,36
Tukey HSD					
1		2	3	4	
	sub	,894	,915	,102	
	obj	,945	,966	,674	
2		1	3	4	
	sub	,894	1,00	,043	
	obj	,945	1,00	,745	
3		1	2	4	
	sub	,915	1,00	,230	
	obj	,966	1,00	,877	
4		1	2	3	
	sub	,102	,043	,230	
	obj	,674	,745	,877	
	Levene Test	Anova Significance	Kruskal-Wallis-H Significance		
sub	0,390	0,041	0,024		
obj	0,888	0,670	0,682		

Size = Team size; N = Number of persons; Mean = Mean value on a scale from 1 = very little to 5 = very much

Table 4: Results on team-building

Size	N	Mean	Std. Dev	Tukey HSD		
1	9	1,44	0,53	2	3	4
				,000	,000	,001
2	70	3,21	1,01	1	3	4
				,000	,813	,917
3	15	3,47	0,64	1	2	4
				,000	,813	,618
4	20	3,05	1,32	1	2	3
				,001	,917	,618
Levene Test		Anova Significance		Kruskal-Wallis-H Significance		
0,029		0,000		0,000		

Size = Team size; N = Number of persons; Mean = Mean value on a scale from 1 = very little to 5 = very much

[4] If one assumes equal variances the significance is 5,1% percent

The following table summarizes the support for the hypotheses.

Table 5: Summary

	2 > 1	2 > 3	2 > 4
fun	no support	weak support	support
immergence	no support	no support	support
activity	support	no data	no data
learning	no support	no support	some support
team-building	support	no support*	no support**

** here: three > two; ** here: four > two*

The significantly increased activity level and team-building justifies to prefer teams of two rather than individual players. There is little significant evidence to prefer teams of two to teams of three. However, the data shows that teams of four are suboptimal: This team size decreases fun and immersion as well as (maybe) learning. There is no evidence that these negative effects are balanced by improved team-building. However, the internal validity of data presented here has to be interpreted with care: They were collected in a field experiment without total control over all variables. Some important effects may have been covered by data noise. Other results may only not be significant due to a small sample size. Particularly, the data on learning effects have to be considered with precaution. Testing factual knowledge may not be appropriate for this kind of learning support; testing know-how should be more appropriate (but also more difficult). Furthermore, the results depend on current technology; improved mobile devices and applications may change them. Thus, further field and laboratory experiments are needed to test the hypotheses.

7. Implications and further research

There is data to support the decision to have teams of two share a game identity in a complex mobile game. There is, however, no data to support the idea of moving to team sizes larger than two. In teams of three, one person may be left out; teams of four may split into two subgroups.

Teams of two currently have surprisingly little support. It may be helpful to provide information over more channels (particularly, on voice and sensory input) in order to reduce the channel overload and to make use of the increasing capability of the younger generation to process information in parallel. An improved support could split channels between the two players: one of them may focus on the navigation while the other person may focus on understanding the tasks, communicating and prevent being caught by other teams. The design of channel splitting is tricky as both players still need to learn what the game is intended to convey.

Researchers and practitioners should take the presented results into account when designing mobile games. First, they should check, whether it is possible to participate as a team of two. They should be particularly careful with providing information in channels that cannot be shared. Secondly, they should make a deliberate choice whether the primarily target individual users or teams of two. Teams of two may use social protocols to handle deficiencies of current technology or the complexity of the situation that are not available for individuals. There are many similar situations in other areas, such as mobile support for museum visitors, support for tourists (the majority of tourists travel in dyads [3]) and for mobile work. Thus, there is a need to study dyadic usage of mobile technology, and we have to find ways to develop better support for them.

As usual in research, a new insight opens up a set of new questions:

- How can a team of two (or more) be supported most efficiently?
- Does the optimal team size change wtih more efficient support?
- What is the influence of the task types on the optimal team size?
- What is influence of the scenario on the optimal group size?

Other researchers are invited to join us in our quest to better understand and support mobile learning with games.

8. References

[1] S. Benford, R. Anastasi, M. Flintham, A. Drozd, A. Crabtree, C. Greenhalgh, N. Tandavanitj, M. Adams, and J. Row-Farr “Coping with Uncertainty in a Location-Based Game”, IEEE Pervasive Computing Journal, July-September, 2003

[2] S. Björk, J. Fals, R. Hansson, and P. Ljungstrand, ”Pirates! Using the physical World as a Game Board”, Paper at Interact, IFIP TC.13 Conference on Human-Computer Interaction, July 9-13, Tokyo, Japan, 2001

[3] B. Brown, M. Chalmers, “Tourism and mobile technology”, in K. E. Kuutti, “Proeceedings of the Eighth European Conference on Computer Supported Cooperative Work”, Helsinki, Finland, 14-18 September 2003, Kluwer Academic Press. 2003

[4] A.R. Dennis, and J.S. Valacich, "Computer Brainstorms: More Heads Are Better than One," Journal of Applied Psychology, 78:4, 531-537, 1993.

[5] K. Facer, R. Joiner, D. Stanton, J. Reid, R. Hull, and D. Kirk, “Savannah: mobile gaming and learning?”, Journal of Computer Assisted Learning. 20, 6, 399-409, 2004

[6] G. Gay, R. Rieger, et al., “Using mobile computing to enhance field study”, CSCL 2: carrying forward the conversation, USA, Lawrence Erlbaum Associates Inc: 507-528, 2002.

[7] J.E. McGrath, “Time, interaction, and performance (TIP): A theory of groups”, Small Group Research, 22(2), 147-174, 1991.

[8] J. Hall, “Mogi: Second Generation Location-Based Gaming” 2001,
Available:
http://www.thefeature.com/article?articleid=100501&threshold=-1. Last access 07.03.2005

[9] F. Lehner, G. Nösekabel, et al., „M-Learning und M-Education, Mobile und drahtlose Anwendungen im Unterricht.“ Regensburg, Lehrstuhl für Wirtschaftsinformatik III, Universität Regensburg, 2003

[10] A. Mitchell, and C. Savill-Smith, “The use of computer and video games for learning.”, Learning and Skills Development Agency, London, 2004

[11] C. O'Malley, G. Vavoula, et al., “WP4 - Guidelines for Learning/ Teaching/ Tutoring in a Mobile Environment”, MOBIlearn (IST-2001-37187), 2003.

[12] B. J. Pine, J. Gilmore, et al., “The Experience Economy”, Harvard Business School Press, 1999

[13] C. Savill-Smith, and P. Kent, “The use of palmtop computers for learning. A review of the literature”, London, LSDA, 2003

[14] B. Schenk, G. Schwabe, „Die elektronische Zukunftskonferenz.“, in: H. Lüttich, C. Rautenstrauch, „Verwaltungsinformatik 2000“, MDV Halle, S.324-340, 2000.

[15] B. Schenk, “Moderation”, in J. Haake, G. Schwabe, and M. Wessner, „CSCL-Kompendium“ Oldenburg, München, 2004

[16] G. Schwabe, „Mediensynchron Lernen - Evaluation und Fortentwicklung der Media Synchronicity-Theorie“, Zürich, 2002

[17] G. Schwabe, and C. Göth, “Mobile Learning with a Mobile Game: Design and Motivational Effects”, Journal of Computer Assisted Learning, 2005, in print.

[18] G. Schwabe, D. Frohberg, „MLearning - Kooperatives Lernen im Kontext“, WISU - das Wirtschaftsstudium 8-9/04, 2004

[19] M. Sharples, D. Corlett, and O. Westmancott, “The design and implementation of a mobile learning resource”. Personal and Ubiquitous Computing, 6:220–234, 2002

[20] G. Stahl, “Group cognition in computer-assisted collaborative learning”. Journal of Computer Assisted Learning, 21:79-90, 2005

[21] D. Straub, and E. Karahanna, “Knowledge Worker Communications and Recipient Availability: Toward a Task Closure Explanation of Media Choice”, Organization Science 9(2): 160-175, 1998

[22] V. Venkatesh, M. G. Morris, et al., ”User Acceptance of Information Technology: Toward a Unified View”. MIS Quarterly 27: 425-478, 2003.

[23] M. M. D. Weal, M. Thompson, and D. DeRoure, “The Ambient Wood Journals - Replaying the Experiene”. Proceedings of Hypertext'03. The fourteenth conference on Hypertext and Hypermedia 2003, Nottingham, UK., 2003.