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mGBL

mobile Game Based Learning

Specific Targeted Research Project

Information Society Technologies

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1 Introduction

The following chapter describes the evaluation of a game which was formed out of game Template 3, called "Digital Economy". As this game is different to the other two games the evaluation was done in another way. It was investigated how game 3 (pervasive game) can be used for an efficient transfer of knowledge in learning situations. Pervasive games present an innovative game model which merges the real world and the virtual world. This game concept is used in conjunction with mobile phones as means of interaction and communication enablers to support learning. The following chapters present the evaluation of game 3 "Digital Economy", which was compared with a conventional case study approach in an empirical study with 100 students in respect to long-term learning results and learning efficiency. The empirical results reveal that game 3 "Digital Economy", leads to higher energetic activation, more positive emotions, and more positive attitudes towards learning content, than the conventional case study approach.

2 Background

Traditional learning methods no longer suffice to fulfil the requirements of a modern teaching structure and do not contribute sufficiently to the acquisition of core competencies such as teamwork, independence, and willingness to take on responsibility. It is against this background that Game Model 3 was developed.

2.1 Mobile technologies as successful information and communication channels

The basic idea of Game 3 is to use the potential of the mobile phone communication channel and combine it with the possibilities of digital learning games in order to create a new and improved learning environment. The concept of pervasive gaming lends itself to this purpose, in that the real world fuses with the virtual world (Walther 2005). In this context, one can speak of pervasive game learning, an expansion of mobile game-based learning.
Pervasive games take place in the real world, and the player communicates with his fellow players and the remote control system via wireless technologies. Various communication channels are available for this, among them the mobile phone. Additional core technologies needed for pervasive gaming are portable displays, which render the digital content tangible in the real world independent of location, and sensor technologies, such as cameras, through which the status of the player can be ascertained (Benford et al. 2005). These technological prerequisites are fulfilled by modern mobile phones, which therefore offer an ideal medium for the execution of pervasive games.

3 Evaluation of the game 3 implementation: "Digital Economy"

3.1.1 Overview of the game idea

The pervasive learning game "Digital Economy", which is one of a huge number of possible games built from game template 3 of the mGBL-project, connects the real and virtual worlds, with the game system requesting students via SMS to find and analyse special everyday situations in the area of "digital economy" (eCommerce). The students work in teams and must document the specified situation and submit a proposal for improvement as quickly as possible by means of MMS. The contributions are then displayed on a website in a mobile blog and, depending on the quality, earn the teams a varying number of points in the high score list. This game concept is presented in detail in the following section and can be easily adapted to other learning topics due to its universal design.
The basis for the draft of the game idea was the creation of a practical learning environment in which the students can deal with the learning topic in the real world. In order to ensure simple and universal application of the game concept in various teaching materials, the game was developed based on the following three core elements:

1. **Indication of a problem**: The students are given a location where there is a problem connected with the learning topic. The students are asked to identify this problem.
2. **Description of the problem**: After identifying the problem, the students must describe the problem and send this description back to the game leader for assessment. The described problem represents a worst-practice situation.
3. **Problem resolution**: Finally, and most importantly, the students must find a best-practice situation for the resolution of the described problem in the real world.

These core elements can be easily adapted by teachers to various learning materials; they simply select a suitable problem as regards the topic to be communicated.

In order to embed the above-mentioned core elements into the game, the students compete in teams in a playful competition to find the most innovative and fastest problem description and problem solution. The reference to a problem is communicated by the game leader in the form of an "opportunity alarm SMS." Then the students must hurry to the specified location and photograph the problem with their mobile phone camera and send it to the game system via an "opportunity MMS," including the accompanying problem description. Then the students must find innovative solution approaches in the real world. Each team is required to find a best-practice situation within a specified time frame and to send a description, including photo, via a "solution

MMS." The opportunity and solution MMS are awarded 0-3 points by the game leader; these are immediately added to the team's high score. A single game cycle consists of several different opportunity alarm SMS, which are randomly sent out after the expiration of the preceding opportunity. This results in a continuously changing score, which contributes significantly to strengthening the game components. Additionally, the dynamics of the game are further increased through the continuous movement of the students in the real world as well as through the notification regarding the contributions by opposing teams. Below examples of an "opportunity alarm SMS", "opportunity MMS" and "solution MMS" are presented:

"Opportunity alarm SMS":

Opportunity alarm 1! Location: Zeughaus (armoury), Herrengasse. Hint: Personal guides – untapped potential of the digital economy? Validity period: Until Dec. 1, 20:00. Opportunity MMS with keyword "dec1" to 0676/80081200. Good luck!

"Opportunity MMS":

Figure 2: Picture to illustrate the problem situation in an "opportunity MMS"

dec1, Problem situation: On a guided tour the guide decides which samples are visited in which sequence, and for how long. Without guidance one can move freely within the museum at individual speed, but with the disadvantage of not getting information about the samples.

"Solution MMS"

Figure 3: Picture to illustrate the proposed solution in a "solution MMS"

del1, Application of a digital guide! Example: Via a "Mobile Space Guide" the Kunsthaus Graz enables one to move freely and at individual speed within the exhibition, while at the same time getting important information about the samples. Visitors receive a Nokia 770 at the entrance with which information regarding samples can be accessed at the push of a button and predefined tours can also be selected.

3.1.2 For Game Model 3 evaluation: a 'Digital Economy' implementation, embedded in the learning context

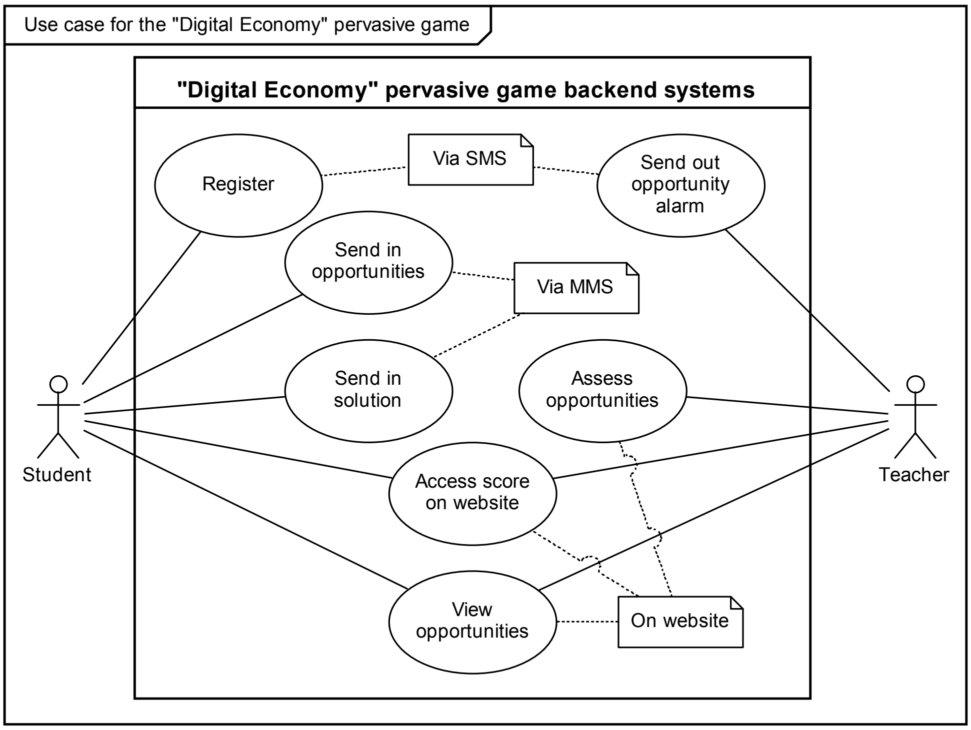
The game idea discussed above is not oriented to specific learning materials. However, in order to test the practical feasibility of the concept, it is necessary to focus on a specific learning topic and actively implement the pervasive learning game into a teaching subject. To this end, we will focus on the topic of "digital economy".

This novel learning approach was first tested during winter semester 2006/07 at the Karl-Franzens University in Graz within the scope of both the "Principles of Digital Economy" and "Modelling of Business Models and Digital Economy" courses and was drafted in conjunction with this study. A focal point of these courses was the communication of the methodological principles of networked thinking and acting in digital economy. Using practical learning, the objective is to show why it is important to concern oneself with business models and the digital economy and how one can handle complex problems. An application-oriented presentation format should teach students networked thinking for the strategic management of a company. Students should also learn how to set objectives and circumvent problems in the digital economy. Moreover, the digital economy sector not only requires new knowledge but also offers completely new possibilities to constantly update this knowledge. Therefore, a central objective is the mediation of the skill of continuously undertaking a knowledge update in the digital economy area through independent work in a new field [Petrovic, home page: http://digitaleoekonomie.uni-graz.at/].
In addition to frontal teaching for the communication of basic facts, case studies and teamwork are suitable for achieving the above-mentioned course objectives, in order to apply the acquired knowledge to concrete problems in business practice. Because the developed pervasive learning game is

considered as an optimization of case-study-based learning, courses on the topic of "digital economy" are especially suited for use in this novel learning environment. Therefore, the following procedure was employed in the above-mentioned courses. First the principles of digital economy were presented by means of a practice-oriented presentation format. Then the students were randomly divided into two groups and in teams of five dealt with the learning topic by means of case studies or pervasive gaming. In order to evaluate the lecture, the results from the case studies and/or the pervasive learning game as well as from a class exercise were consulted. For the last evaluation criterion, the students were supposed to present proof about the skills of understanding, application, analysis, synthesis, and evaluation of the learning material in a written examination.

3.1.3 System-oriented implementation

Building upon the use cases, this section presents the system-oriented implementation of the developed pervasive learning game environment. Through the systematic stringing together of the use cases, the logical game cycle can be illustrated in an activity diagram. Based on this activity diagram and the use cases, the pervasive game is implemented via a software connection of the various user interfaces. The use cases define the interactions between the actors and the observed system that occur during the course of the game. Each use case always describes exactly one action or one process. Illustration of the use cases therefore enables an elementary description of the developed game concept. For an overview of the most important use cases that occur in the "Digital Economy" pervasive learning game, see Figure 4. The systematic cycle of the game that results from piecing together the use cases is illustrated in an activity diagram (Figure 5).



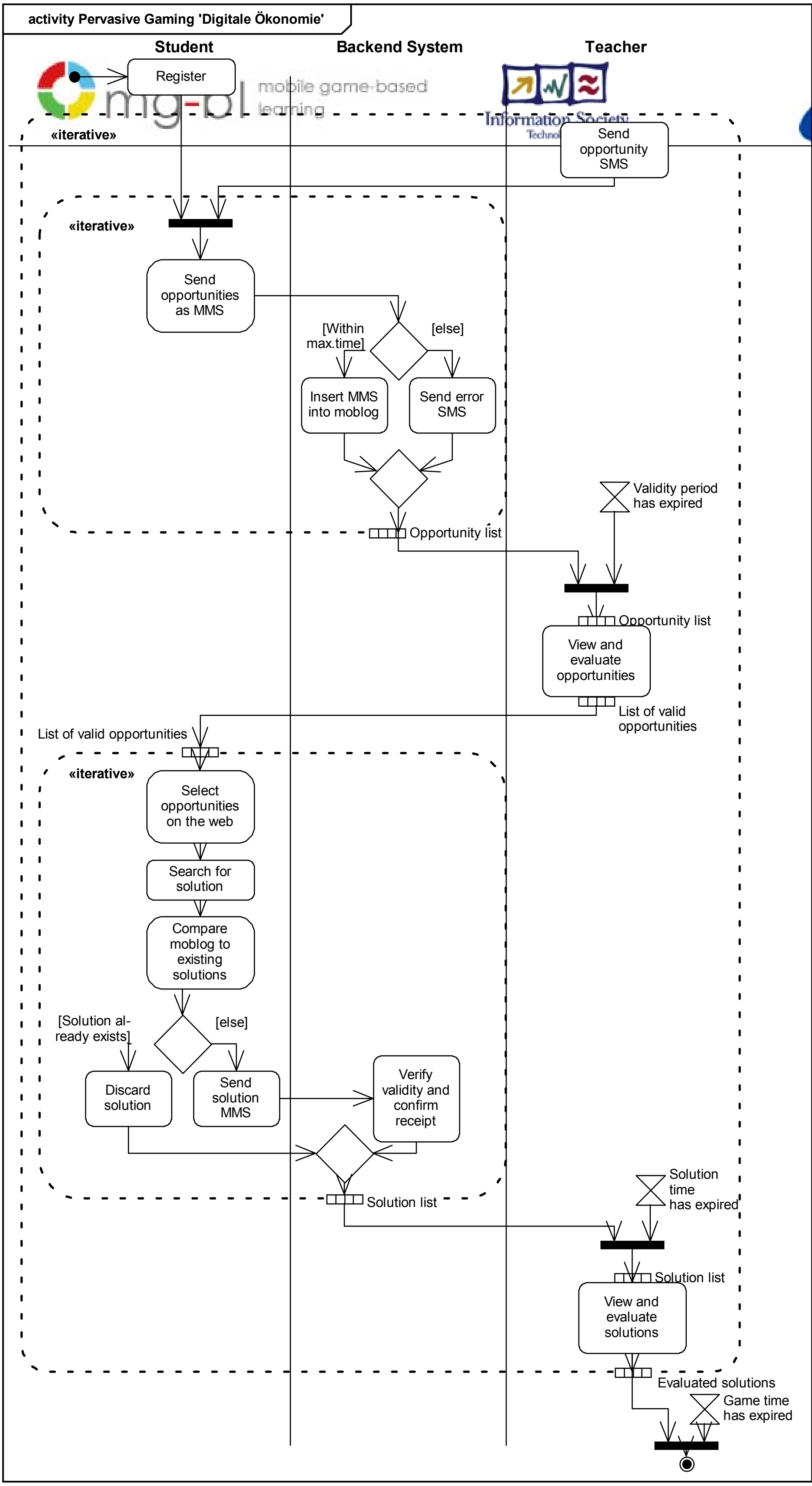


Figure 4: Use cases of the "Digital Economy" pervasive game
Figure 5: Activity diagram of the "Digital Economy" pervasive game

The backend system, which was developed for the "Digital Economy" pervasive game with the use of the Eclipse development environment and the JBoss application server, is illustrated in Figure 6. The core of the system is the Game Engine, which controls the entire cycle. It is here that it is determined at runtime how incoming SMS or MMS with specific key words will be responded to, when certain time frames (for example, for the transmission of opportunity or solution proposals) are open, and which messages will be sent to the mobile terminals in the event of errors. The Game Management module enables easy management of these parameters via a web interface. The overall playing mechanics as well as the transactions are stored in a relational database (MySQL), which is accessed with standard SQL protocols. An O/R mapper (Hibernate) takes over the abstraction from the object-oriented application and relational data layer. Communication with the frontends (PC via web browser or mobile phone via SMS and MMS) is controlled by the respective interfaces. The backend also makes available the functionalities for the use of the moblog, via the UI libraries.

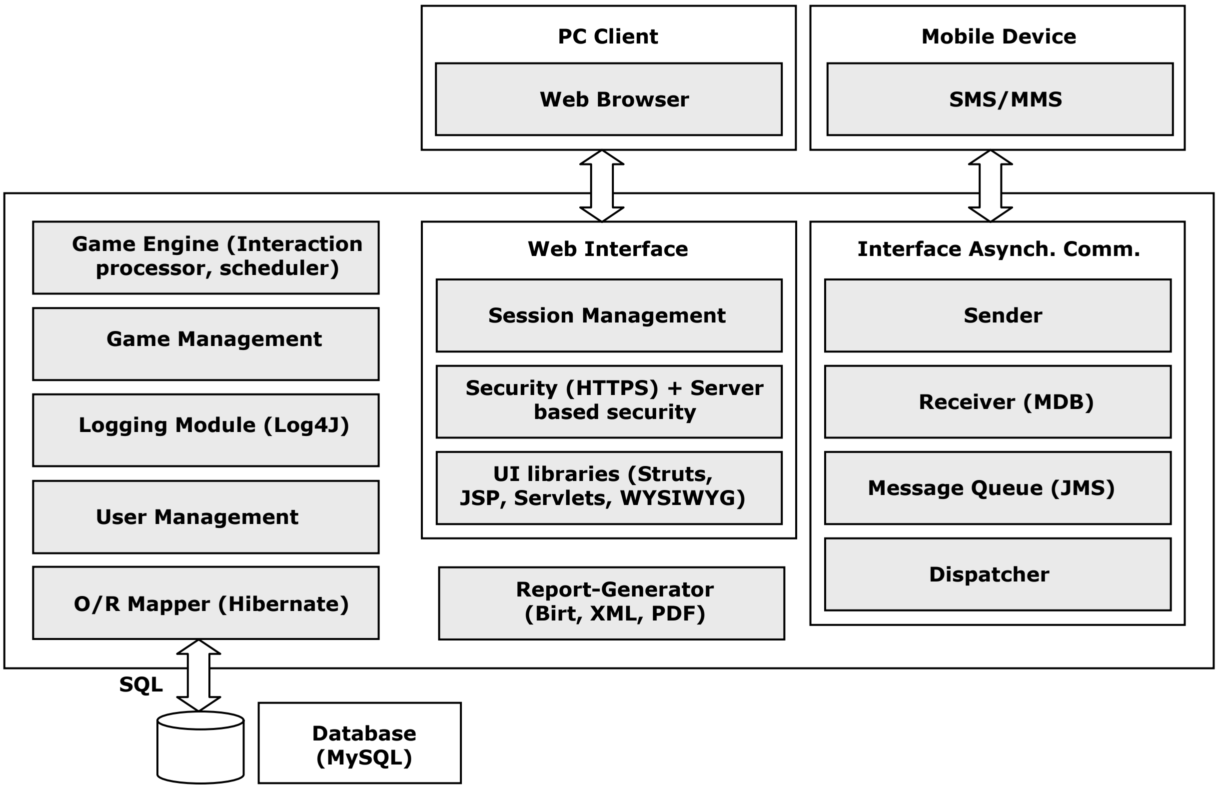


Figure 6: System architecture of the "Digital Economy" pervasive game

3.2 Study design

The pervasive learning game developed in the scope of this study is intended to serve for the efficient communication of long-term knowledge that can be successfully employed in subsequent professional life. Evaluation of the long-term effect and practicability is not immediately achievable, however, because as a rule the learners cannot be observed for the required very long time frames. Therefore, a general study methodology was selected that investigates the development of activating and cognitive processes in learners. Based on the effects of the learning method on the activating and cognitive processes, conclusions can then be drawn about the long-term effects, the practical feasibility of the knowledge, but also about the learning efficiency, for example. This approach to evaluating the learning success is sensible, because activating and cognitive processes serve to describe and explain human behaviour (Kroeber-Riel and Weinberg 2003, Trommsdoff 2004) and learning is defined as a change of behaviour in specific situations (Edelmann 2000).

3.2.1 Measuring the effect constructs and the flow experience

The activating processes are critically important to the explanation of behaviour, because they supply the individual with energy and place the individual in a state of motivation and productivity (Kroeber-Riel and Weinberg 2003, Trommsdorff 2004). Within the effect analysis we observe activating processes based on the "activation," "emotion," and "attitude" constructs. These constructs split into several effect dimensions and can be determined by means of standard indicator scales. Details about the individual effect dimensions and the scales employed are illustrated in Table 1.

The cognitive processes, which serve primarily to deliberately control mental behaviour, are comprised of the processes of information assimilation, information processing, and information storage (Kroeber-Riel and Weinberg 2003). Our study investigates the development of these processes by means of an individual knowledge test that focuses on the interrogation of practical knowledge (see Table 1). The students were also interviewed about their subjective learning success.

In addition to the evaluation of the development of the effect constructs, we are interested in how much more pronounced the flow experience (Csikszentmihalyi 2000) is for a pervasive learning game than for conventional learning methods. Therefore, the flow scale (short version) according to Rheinberg (Rheinberg et al. 2002) (see also Table 1) was used.

Also of interest is whether the flow experience is a decisive factor behind a possibly positive effect of the pervasive game in the learning process. This assumption stands to reason, as several studies (Drengner and Zanger 2003, Schiefele and Roussakis 2006) have reported a strong connection between the flow experience and mental activation as well as a connection with positive emotions. Such a connection would be reflected in correlations that transcend the effect of the learning method.

Table 1: Overview of the indicator scales used

Construct	Dimensions	Indicator scales
Activation	Energy activation Tenseness	Activation-Deactivation Checklist (AD-ACL) according to Thayer [Thay89] German translation: by Imhof (Imhof 1998)
Emotion	Interest, joy, surprise, rage, disgust, disdain, shame, guilt, fear, sadness	Differential Emotions Scale (DES) according to Izard (Izard 1977), German translation: by Merten and Krause (Merten and Krause 1993)
Attitude to learning material Attitude to learning method	Activity, evaluation, strength	Semantic differential according to Osgood et al. (Osgood *et al.* 1975]
Information assimilation, processing and storage	Individual knowledge test	Test of practical knowledge: ten questions, assessment with grade
	Subjective learning success	Student interview
Flow experience	Flow value	Flow scale (short version) according to Rheinberg (Rheinberg *et al.* 2002)

3.2.2 Hypotheses

Based on the characteristics of pervasive games discussed above, it can be assumed that such games are more effective than conventional learning methods. The following hypotheses regarding the development of effect constructs can be derived from this in our empirical study:

Relative to conventional case studies, the "Digital Economy" pervasive game produces:

(H1.1) An increased energy activation

(H1.2) More positive emotions

(H1.3) A more positive attitude vis-a-vis learning material

(H1.4) A more efficient transfer of knowledge

Furthermore, the following hypotheses can be made in connection with the flow experience:
(H2.1) The "Digital Economy" pervasive game produces a stronger flow experience than the conventional case study.
(H2.2) A strong flow experience is associated with mental activation and positive emotions, which is reflected in positive correlations with these constructs that transcend the effect of the learning method.
The correlations between the individual hypotheses are illustrated in Figure 7. It must be noted that the illustrated constructs comprise several dimensions in each case. This study does not include a detailed discussion or a verification of the measurement model for the individual effect dimensions (see Table 1),

because the reliability of the employed standard scales was already comprehensively tested in published literature.

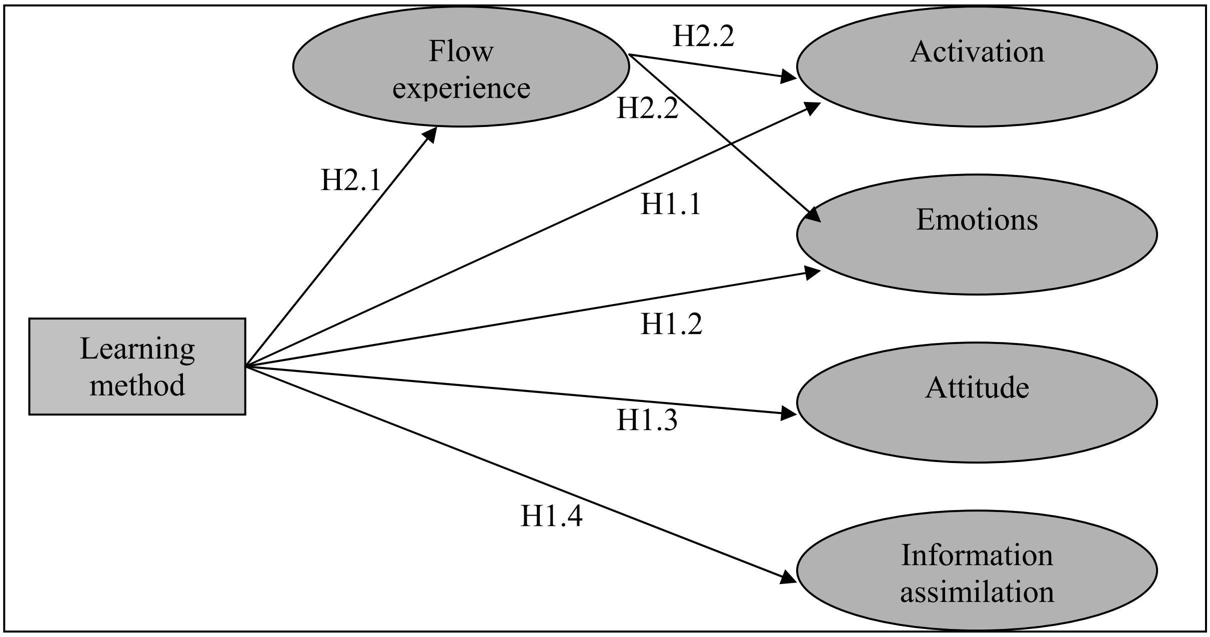


Figure 7: Correlations between the hypotheses

3.2.3 Study process

The above-mentioned hypotheses were tested by means of an empirical study. To this end, a total of 100 students were randomly assigned to two groups, the control and the experimental group, in two courses at the Karl-Franzens University in Graz. The control group had to deal with the topic of "digital economy" within the scope of a conventional case study. In the experimental group, the conventional "case study" learning method was omitted; instead students were to be taught the same learning material by means of the "Digital Economy" pervasive game. In order to enable all students of the second group to participate in the pervasive game, MMS-capable mobile phones were lent out to the students for the duration of the game. The pervasive game and the case study were both conducted at the same time over the course of two weeks in December 2006 and in January 2007.

3.3 Results of the empirical study

3.3.1 Multivariate variance analysis

The experiment in the study design was conducted in two different courses for the same topic but at different times and with different students. Therefore it was not ensured a priori whether the data sets gathered from the two courses could be viewed in a uniform manner. A multivariate variance analysis (MANOVA) was therefore conducted at the start of the evaluations with the learning method (case study or pervasive game) and the course groups (first and second course) as fixed variables. The dependent variable employed was all effect dimensions illustrated in Table 1 (including flow values, knowledge test, and subjective learning success). The conducted MANOVA clearly shows that the learning method affects the development of the knowledge constructs (probability of error less than 0.001). In contrast, the affiliation with a specific course group has no significant effects (probability of error of 0.833) on the effect constructs. Likewise, the interaction effects between the learning method and the course group is negligible (probability of error of 0.995). Therefore, the data sets from both course groups can be combined and viewed in a uniform manner.
The following section discusses the effect constructs in detail, whereby the dependency of the learning method (case study or pervasive game) is analysed. Differences in the individual constructs are considered significant when the MANOVA exhibits a probability of error of less than 5% for this dependent variable; a value of less than 1% is designated as highly significant. The mean values for the respective learning method, the employed scale range for illustrating the measurement, and the probabilities of error for significant group differences are illustrated for all effect dimensions (other than the less developed emotions of rage, disgust, disdain, fear, shame, and guilt) in Table 2. The determined results confirm hypotheses (H1.1)-(H1.4) as well as (H2.1) and are discussed in more detail in the following section. Furthermore, Table 3 illustrates the correlations between the flow value and several effect dimensions. These results show significant positive correlations in both learning groups (pervasive game and case study) between the flow experience and the energy activation, interest and joy, which also corroborates hypothesis (H2.2).

Table 2: Development of the effect dimensions

Construct	Scale	Dimensions	Perv. game[1]	Case study[1]	Significance[2]
Activation	0 (not at all) - 3 (very strong)	En. activation	2.282 (0.090)	1.763 (0.091)	.000
		Tenseness	1.153 (0.080)	1.270 (0.081)	.302
Emotion	0 (not at all) - 4 (very strong)	Interest	3.918 (0.107)	3.370 (0.109)	.001
		Joy	3.203 (0.119)	2.499 (0.121)	.000
		Surprise	2.374	1.652	.000

			(0.123)	(0.125)	
		Sadness	1.351 (0.084)	1.708 (0.085)	.004
Attitude to learning material²	1 (very positive) - 7 (very negative)	Activity	2.668 (0.176)	2.991 (0.179)	.202
		Evaluation	2.406 (0.156)	2.838 (0.159)	.056
		Intensity	2.556 (0.125)	3.013 (0.127)	.012
Attitude to learning method³	1 (very strong) - 7 (not at all)	Activity	2.531 (0.122)	4.079 (0.141)	.000
		Evaluation	2.705 (0.121)	3.558 (0.110)	.000
		Intensity	3.147 (0.101)	3.626 (0.100)	.000
Flow experience	1 (low) - 7 (high)	Flow value	5.033 (0.123)	4.314 (0.125)	.000
Information assimilation, processing and storage	1 (very good) to 5 (insufficient)	Knowledge test	3.401 (0.174)	3.793 (0.177)	.117
	1 (very positive) - 5 (very negative)	Subjective learning success	1.820 (0.068)	2.180 (0.079)	.000

¹ Mean value (standard error)
² 2-sided
³ Measurement after the end of the experiment (case study or pervasive game)

Table 3: Flow effect correlations

		Energ. Activation	Tense-ness	Interest	Joy	Sur-prise	Sadness
FLOW – Per. game	Correlation acc. to Pearson	.439**	-.133	.369**	.413**	.135	-.361*
	Significance¹	.002	.363	.009	.003	.354	.011
FLOW - Case study	Correlation acc. to Pearson	.331*	-.356*	.534**	.325*	.043	-.427**
	Significance¹	.023	.014	.000	.026	.773	.003

¹Significance: ** Probability of error < 1%; * Probability of error < 5%.

3.3.2 Activation effects

The energy activation is significantly higher in the pervasive game than in the case study. This is important inasmuch as the energy activation dimension is viewed as a prerequisite for affective and cognitive processes. It significantly strengthens the processes of information assimilation, processing and storage. The energy activation is also considered a basis for a high degree of motivation and productivity (Kroeber-Riel and Weinberg 2003). A state of high activation is also associated with a positive mood and a sense of well-being (Thayer 1978).. The high degree of energy activation also substantiates the assumptions of Thomas (Thomas 2005, Thomas 2006a) regarding the activating effect of pervasive games.

Table 4 contains a comparison of the results of the activation measurement with the results gathered by Imhof (Imhof 1998), who ascertained the activation dimension during a break and towards the end of a typical course lecture. Although comparing data of two unrelated studies is always critical due to many uncontrolled variables that could account for the differences, it is nevertheless interesting to do so and can at least yield important questions for further research. Compared to the conventional course lectures researched by Imhof, the "Digital Economy" pervasive learning game shows a clearly increased energy activation, which confirms the extraordinary activation potential of the game. Although the energy activation in the case study is clearly less than the value in the "Digital Economy" pervasive game, it is still somewhat higher than it is in conventional lectures (see Table 4). In summary, this comparison suggests that the case study activate students more than conventional lectures, but by far not to the level of the pervasive learning game.

The tenseness dimension is associated with anxiety, agitation, tension, and stress (Thayer 1978, 1989). Because this dimension is not very pronounced in either of the learning methods, it is assumed that the students did not find themselves in a direct stress situation in either of the learning methods. Despite the low tenseness values for the case study and the "Digital Economy" pervasive game, these measurements are slightly higher than the values for conventional course instruction (see Table 4). This slight increase is comprehensible, because case-study-based learning and pervasive gaming requires more individual responsibility from students and thus also causes more tension and stress. Nevertheless, these tenseness values are still so low that they need not be associated with any negative effects.

Table 4: Comparison of various activation measurements

Permitted scale values between 0 (minimum) and 3 (maximum); measurements by [Imho98] were correspondingly scaled.	**Sample**	**Dimension A: Energy activation**	**Dimension B: Tenseness**
This paper;	**Pervasive game**	2.28	1.15

Topic: digital economy	**Case study**	1.76	1.27
Measurements during a break (A, at 12:00 p.m.) and towards the end (B, at 1:00 p.m.; C, at 3:00 p.m.) of the course lecture [Imho98]	**Group A**	1.68	0.76
	Group B	1.65	1.00
	Group C	1.28	0.85

3.3.3 Affecting emotions

The existence of very positive emotions among the participants of the pervasive game confirms hypothesis (H1.2) and is consistent with the experiences reported in previously conducted studies on learning games (Conati 2002). Strongly pronounced emotions such as interest, joy and surprise also form an important prerequisite for a positive attitude vis-a-vis the learning material and a longer memory retention as regards the experiences gained from the game.

3.3.4 Affecting attitudes

The "Digital Economy" pervasive game changes people's attitude to learning material in a positive manner, which is especially and strikingly evident when comparing the measurements taken before and after the experiment. This quality exceeds all the previously known accomplishments of pervasive learning games and constitutes an important new finding of the present study. The positive attitude is particularly important for the penetration of the learned material into the long-term memory. If a student's attitude towards the learning material is bad, then the student will only learn because of outside pressure, which negatively affects the subsequent retrievability of the acquired knowledge.
In addition to the attitude towards the learning material, the attitude towards the learning method was also studied. Measurements taken after the conclusion of the experiment show that the attitude towards the pervasive game is clearly better than the attitude towards the case study. This indicates a high degree of acceptance and fun while playing, and substantiates previous experiences from pervasive learning games (Thomas 2005). It has also been proven that learners generally respond more positively to learning games than they do to other learning methods. But an important factor in the present study is that the positive attitude toward the game can truly be converted into learning capacity.

3.3.5 Effects on Information assimilation, processing, and storage

The knowledge test focused on interrogating practical knowledge, and yields better results for students in the pervasive game group. However, the 0.117 significance of the difference was over the 5% probability of error. As

mentioned above, it must be noted that a knowledge test cannot evaluate all aspects of learning. For example, the penetration of the learned material into the long-term memory, the applicability in practical situations, and the acquired experiences cannot be tested.
In this context, the subjective learning success is an important indicator for the learning capacity. In a student survey, the learning success achieved with the pervasive game was evaluated as being significantly better. This survey was conducted after the case study / the pervasive game were completed and consisted mainly of the following items to measure the perceived influence of the two methods on learning success and learning process.
The item related to perceived influence on learning success read: I believe that the [case study]/[pervasive game] had the following influence on achieving the learning targets of this class:

○ a very positive influence
○ a rather positive influence
○ no influence
○ a rather negative influence
○ a clearly negative influence

The item related to perceived influence on learning process read: I believe that the [case study]/[pervasive game] had the following influence on the learning process (enjoyment and fun at learning, interest in the subject matter, etc.) of this class: (same scale as above)
The positive finding vis-a-vis the pervasive game is consistent with the other effect dimensions and may indicate an efficient knowledge transfer, even if the difference in the objective knowledge test was not significant.

3.3.6 Effects of the flow experience

A great deal of attention was placed on the flow experience in this study due to its close association with intrinsic motivation and unforced action. In principle, the empirical assessment (see Table 2) shows that the pervasive game produces a significantly stronger flow experience than the simultaneously conducted case study. In addition to the associated positive effects, the following section compares the measured absolute values of the flow with other activities in order to gain a better idea of the motivating effect of the pervasive game.
The present data confirm existing studies regarding the flow experience in games (Rheinberg et al. 2003, Schiefele and Roussakis 2006). The results show that the pervasive game produces a much stronger flow experience than the conventional case study. The strong flow experience points to a high degree of intrinsic motivation in the learner and suggests that the game is being played for the game itself and not due to an external incentive, e.g., a good grade. This free choice is an important basis for the transfer of practical knowledge and practical experience. The high flow value is also an indication for a sensible balance between the level of difficulty of the task and the skill level of the learner (Csikszentmihalyi 2000). This equilibrium confirms that the

"Digital Economy" pervasive game neither overburdens nor insufficiently challenges the learner and thus creates good preconditions for motivated learning.
In order to better asses the observed flow values, Table 5 compares the results gathered within the scope of this study with empirical data from other samples. It is evident that the flow value observed in the pervasive game is very high compared to the values reported in another study. While a higher value (5.16) was observed only in graffiti sprayers, the flow values for solving statistics problems were significantly lower, both during and after a lecture. In contrast to the pervasive game, the case study does not seem to differ from the flow values for a lecture or for the solving of statistics problems (see Table 5). Although one must take into account that the data from the other study was collected in different conditions, with different students, by a different researcher, etc. the relative higher flow value for the pervasive game indicates a particularly motivating effect.

Table 5: Flow values for various samples (data for activities 3-6 from (Rheinberg *et al.* 2003)

Activity (sample size)	Mean flow values
1) "Digital Economy" pervasive game (N=49)	5.03
2) "Digital Economy" case study (N=47)	4.31
3) Graffiti spraying (N=292)	5.16
4) Statistics problem (N=123)	4.57
5) Lecture – middle (N=63)	4.43
6) Lecture – end (N=63)	4.21

The correlations between the flow value and the effect dimension illustrated in Table 3 substantiate the assumption that the flow experience is an important factor for the development of the "activation" and "emotion" constructs. The present results are consistent with known research results that associate the flow experience with positive activation, a high degree of interest, and a high degree of motivation [Schiefele and Roussakis 2006].

4 Conclusions

The "Digital Economy" pervasive game presents a modern, multifaceted learning environment that was developed to cope with current problems in knowledge transfer. The potentials of mobile phones were used in a targeted manner as an individual communication and information channel in a pervasive learning game. The results of current research were taken into account in the development of the game concept and the subsequent system implementation in order to optimally achieve the positive characteristics of mGBL game templates.

Subsequent to the development, the pervasive game was tested in the learning context with regard to the topic of "digital economy" and compared to a conventional case study. The assessment of the accompanying empirical study shows a very positive effect of pervasive games. Compared to the conventional learning method of the case study, the pervasive game produces a higher degree of activation, more positive emotions, an improved attitude towards learning material, and also greater learning success.

Moreover, a significantly greater flow experience was observed in students in the pervasive game. Beyond the influence of the learning method, the degree of the flow experience correlates with the positive effects and can therefore be considered a decisive factor for the success of the pervasive game. This result confirms the correlations between the flow experience and the activation and emotion constructs discussed in published literature (Schiefele and Roussakis 2006, Drengner and Zanger 2003).

The above results show that the pervasive game offers a good alternative to the rigid structures of conventional learning methods. The pervasive game leads to higher energetic activation, more positive emotions, and more positive attitudes towards learning content..

An advantage of the game presented in this paper compared to previous pervasive games is the high degree of mass production capability of the system, which occurs through the use of widely distributed mobile terminals. In contrast to technically complex pervasive games, the course instructor only needs an operational backend system with the corresponding software. In this manner, the basic economic preconditions for a sustainable diffusion of this technology are fulfilled.

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