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mGBL

mobile Game Based Learning

Specific Targeted Research Project

Information Society Technologies

### **D 7.5 – Evaluation report on the final test bed incl. content**

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TRIESTE

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<b>PP</b>	Restricted to other programme participants (including the Commission Services)	
<b>RE</b>	Restricted to a group specified by the consortium (including the Commission Services)	
<b>CO</b>	Confidential, only for members of the consortium (including the Commission Services)	

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## 1 General Deliverable information

This section provides general information about the deliverable.

They are:

- General Deliverable Description
- Revision history
- External peer-review (internal, not part of the public deliverable)
- Executive Summary of the Deliverable

### 1.1 General Deliverable Description

WP number:	<b>WP7</b>
WP name:	<b>Evaluation and Validation</b>
Deliverable number:	<b>D7.5</b>
Deliverable name:	<b>Evaluation report on the final test bed incl. content</b>
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Involved project partners:	<b>SAB, Ultralab, PFRI, FFRI, TRIESTE, Aster, UM, AZM-LU</b>

Table 1: General Deliverable Description

### 1.2 Revision history of this document

<b>Date</b>	<b>Version</b>	<b>Description</b>	<b>Author</b>
8/10/2008	0.1	Base version	Gaion
15/10/2008	1.0	Revisions and partners contributions	Mininel
21/10/2008	1.1	Revisions according to 1 <sup>st</sup> reviewer comments	Mininel, Gaion
31/10/2008	1.2	Revisions according to 2 <sup>st</sup> reviewer comments	Mininel, Gaion, Vatta

### **1.3 External peer-review (internal chapter, not part of the public deliverable)**

This section contains a description and an overview of the results of the external peer-review of the deliverable. This is an internal chapter (consortium, Project Officer and reviewers) and will be removed within the final public version of the deliverable.

#### *1.3.1 General description of the review process*

**Reviewer 1:** Raffaele Pesenti is Full professor of Operations Research. Department of Applied Mathematics, School of Economics and Business, University Ca' Foscari of Venice. His scientific activity is in the field of management and evaluation of complex systems with application in transportation/logistics and biology. Interests are particularly devoted to:

- Management of distribution networks and systems (robust control of production-distribution systems, consensus problems, polyhedron-zonotope containment),
- Transportation (dynamic routing, air transportation economic models),
- Production planning and control (scheduling and inventory problems),
- Innovation and evaluation problems (data envelopment analysis models, decision support systems),
- System biology (phylogenetic inference problems, relationship between molecular connectivity and biological activity).

Pesenti has been teaching at academic level for 12 years.

**Reviewer 2:** Paolo Bruno is PhD in Information Engineering, with a major in Bioengineering. His scientific activity and his teaching curriculum are in the fields of Bioengineering, Computer Science, Information System Technologies, Medical Informatics, Bioimaging, Hospital and Clinical Information Systems, Electrotechnics.

### *1.3.2 Comments and Recommendations of the External Reviewers*

#### **Reviewer 1:**

This document addresses in an interesting way the difficult path of evaluation of the effectiveness of a mobile game-based learning system. However:

- 1) a better clarification is needed, for improved comprehension, of how the weights of characteristics and dimensions are calculated;
- 2) pay attention to the language correctness.

#### **Reviewer 2:**

Interesting and reasonably well documented by bibliography approach to the evaluation problem.

- 1) One might argue that final users of the mobile game-based learning system tested are really students. Original LeVIS index only approach final user's perceived value and satisfaction. Why the choice to include professors?
- 2) Take care to details: many tables are not well readable and/or need reformatting. Mostly, all tables exhibit an unjustifiably high number of significant digits.

### *1.3.3 Justification and actions/corrections taken regarding the external peer-review*

Comments from 1<sup>st</sup> reviewer were accepted. Parts of text explaining more clearly the steps to reach final effectiveness value were added and a final thorough check of language correctness was made.

Comment 2) from 2<sup>nd</sup> reviewer accepted and all the table were corrected accordingly.

Regarding comment 1) of 2<sup>nd</sup> reviewer, it was a deliberate choice throughout the whole project span to consider both professors and students, with their different roles, as final users of the system and thus any change in this approach would have been unjustified now.

## **1.4 Research Background**

This work is based on D7.1, D7.2, D7.3, D7.4, D6.3 and D6.4 and is the final evaluation report based on last round of User Trials, whose results are fully described in D6.4.

## **1.5 Executive Summary of the Deliverable**

D7.5 “Evaluation report on the final test bed incl. content” is the final evaluation report based on last round of User Trials. An evaluation scenario has been developed in order to create a common assessment platform.

The benchmarking tools used are the Value-Satisfaction grids and LeVIS index, which have been selected as optimal to provide a general conceptual framework including overall perceived satisfaction with mGBL system, overall perceived value of system, behavior or usage with respect to mobile learning systems and perceived system effectiveness. Perceived effectiveness of mGBL system is evaluated at 75,51 %. This final aggregated marks the mGBL system as a high effectiveness system according to the LeVIS Index of Satisfaction.

## 2 Introduction

The specific aim of the mGBL project is to design, develop and trial a prototype game platform that can be used to efficiently develop games for m-learning, whereby the focus was on the support of decision making in critical situations, not only in a cognitive but also in an emotional way. These games should firstly directly support learning via opportunities to develop knowledge and cognitive skills in an exciting and inspiring – thus in a highly emotional – way, and secondly, indirectly motivate users to refer to other media for learning purposes.

Measures of project success are usually designed around a set of general principles or building blocks that guide the essential decisions in putting together an evaluation plan and keeping it under review.

The project evaluation methodology is based on the ground of mGBL D7.1 “Evaluation plan”. Previous user trial evaluation rounds aimed at supporting the development of the different phases and of the outputs foreseen in the project development. This final evaluation of the results of the third user trials examines the outcomes and impact of the project in a full educational context, where final prototypes of platform and games have been trialed during lessons and courses, as can be seen in D6.4.

It is important to keep in mind that, although based on the same set of data, collected during the third user trials, this document and the deliverable D6.4-mGBL have completely different objectives and methodologies. In D6.4 the aim is a detailed analysis of the data from the third user trials, that can produce useful insights regarding approach by students and professors to mGBL platform and games and more in general towards game-based learning. The objective of WP7 is the evaluation and validation of the mGBL project in the light of the same last round of user trials. Analysis and elaboration of collected data is focused on the calculation of objective indexes of efficiency of the proposed mGBL system, thought as part of a possible wider e-learning platform.

WP6 and WP7 thus cover, regarding 3rd User Trials data, the well distinct roles of “analysis” for the improvement of project outcomes and “evaluation” with synthesis to assess the overall performed work. To this end, different methodologies with different objectives have been appropriately selected and implemented.

The project has involved significant effort in terms both of technical development and experimentation in real-world learning environments. One of the most critical questions posed by this kind of project, and shared with other use of games in educational settings, is whether learning is taking place as a direct result of the game-playing activity.

The evaluation of game playing activity in this pedagogical context is a complex issue, which demands consideration of a wide range of variables within the context of particular approaches to pedagogy and embraces temporal considerations of learning retention. The social context of mobile game playing means that it is impossible, and indeed undesirable, to focus purely on learning. The use of advanced technologies makes the question of learning evaluation even more complex, since students are discovering and building upon both subject knowledge and technical skills.

Problems in assessment of the value of mobile game based learning system have to be divided in few different parts, considering differences between the technologies used in project.

For example, for gaming there is a problem of defining the elements that make an experience engaging, because there is no stated measure for that. Both the film industry and the computer game industry use a business model in which a few hits cover the costs of many flops. Given the millions of dollars at stake, it is reasonable to expect that a systematic approach to successful development would be used if available. So it is hard to suggest that there is any recipe or procedure that guarantees engagement. Nevertheless Tom Malone investigated the elements that make computer games fun to play (Malone, 1981). He posited four elements that were abstracted from his research: challenge, fantasy, curiosity, and control. *Challenge* required a

reasonable level of difficulty, *fantasy* meant having a compelling setting for the game action, *curiosity* included the games' having random events and not being completely deterministic, and *control* meant that the students had choices to make.

Based on previous problems, an evaluation scenario has been developed in order to create a common assessment platform. As in any process user roles should be identified. Two user roles are proposed – students and teachers, each having different expectations from the system. Through mGBL user trials it is necessary to create an active environment in which students and teachers are able to realize new way and opportunities for learning.

New technologies are interactive and it is now easier to create environments in which students can learn by playing games, receive feedback, and continually refine their understanding and build new knowledge. Also, the teachers must learn how to use a new technology and to model the learning process for students. At the same time they gain new insights on teaching by watching their students learn. That can stimulate teachers to think about the processes of learning, whether through a fresh study of their own subject or a fresh perspective on students' learning.

### 3 Theoretical considerations

As Chapters 1 and 2 of D7.2 show, the use of games in education has a rich background of studies and applications which demonstrated their usefulness.

Probably the most important thing that should be always kept in mind is that mGBL means **mobile game**-based learning.

Emphasis has to be put on mobile, to remind that we had to adapt pedagogical contents to hardware means that exhibit severe limitations, particularly in computing power and display dimensions, in comparison with the “classical” Computer Based Training. Emphasis should be also put on game, to remind that many previous projects (both private or of public funding) aiming at

applying the “edutainment” concepts failed for an excess of “pedagogy”, forgetting the fact that a game must maintain its “gamish” fundamental characteristics of being appealing, enjoyable, re-playable etc. etc..

The full load of classic pedagogical concepts could not be applied to mGBL project, but a part of it must be adapted to be able to be used appropriately in this context and with current hardware limitations.

In the same way, it is not appropriate to apply classical techniques “as they are” used in evaluation of pedagogical systems, but rather only a subset suitable to this particular context.

Evaluation of methodology can rely on more widely accepted methods and techniques widely used in the field of software development in general, and particularly in development of games and mobile applications and e-learning systems, as stated in D6.1 and D7.1.

#### **4 Evaluation strategy**

As far as evaluation strategies for e-learning systems are concerned, an extensive literature review is provided by Yair Levy in “Assessing the Value of E-Learning Systems” [Levy 2005], pulling theories from the field of information systems, psychology and cognitive sciences, distance and on-line learning, as well as marketing and decision sciences. The review offers a set of benchmarking tools, such as the Value-Satisfaction grids and LeVIS index, to help administrators of e-learning programs understand the potential and effective characteristics of their programs. Most measures of systems' effectiveness developed in industrial fields looked at the satisfaction or users' perceived satisfaction. On the other side, Levy's tools provide the rationale behind the limitations of measuring only learners' satisfaction in the attempt to understand the true system effectiveness in the context of e-learning systems. Although his work is thorough, in mobile learning all Levy's tools and indexes could be used only when m-learning is a part of a whole e-learning university system. Furthermore, in mGBL project, we have two different groups of users:

students and professors, which are both involved in the process, and both have an active part in system usage. Therefore, as a prior step in the mGBL project, LeVIS general conceptual model has been appropriately modified to meet these needs, as shown in Figure 1. The adopted model provides a general conceptual framework including overall perceived satisfaction with mGBL system, overall perceived value of system, behavior or usage with respect to mobile learning systems and perceived system effectiveness.

This proposed model provides a unifying framework for measurement of system effectiveness, using concepts of m-learning value and satisfaction with system.

Given that literature suggests that value and satisfaction are two distinct and uncorrelated constructs, we conducted separate analyses for value and satisfaction, i.e., value and satisfaction measures performed separately and with different factors/characteristics).

Value and satisfaction concepts will be divided into different dimensions **D**, which will be subdivided into basic characteristics **c**.

The proposed characteristics of value of mGBL m-learning system are:

1. learning value,
2. workload,
3. perceived learning,
4. understandability,
5. usefulness

while the characteristics of satisfaction with mgbl m-learning system are:

1. experience,
2. content,
3. playability
4. ease of use

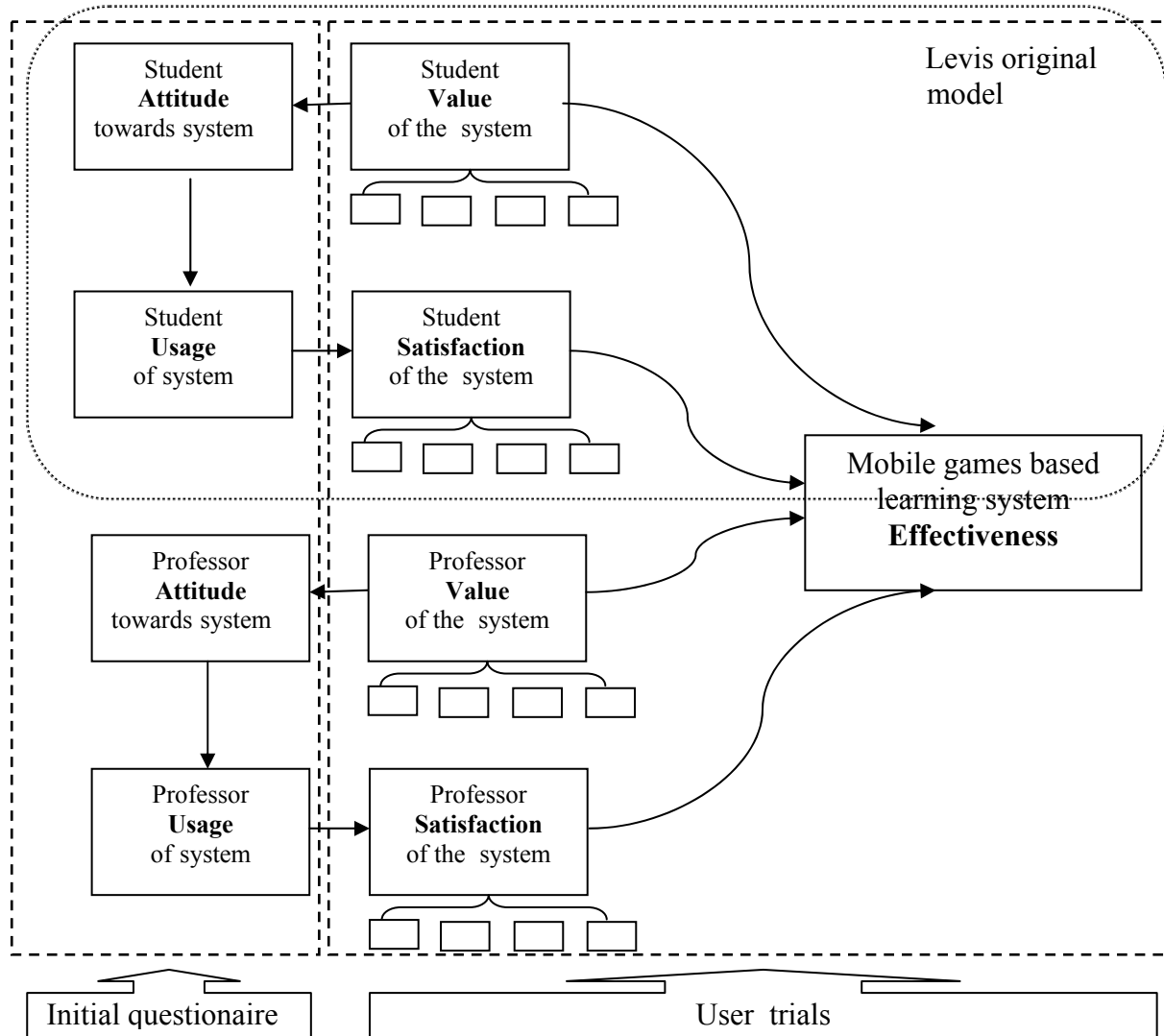


Figure 1: General conceptual model

Total effectiveness can be defined as:

$$[1] \quad Ef_{mgbl} = \sum_{i=1}^2 \gamma_i \sum_{j=1}^2 \theta_{ij} D_{ik} = \sum_{i=1}^2 \gamma_i \sum_{j=1}^2 \theta_{ij} \sum_{n=1}^m \delta_{ijn} C_{ijn}$$

where  $\gamma$ ,  $\theta$  and  $\delta$  are the weights for dimensions D and characteristics c.

The most problematic part of this research is the calculation of the  $\gamma_i$ ,  $\theta_{ij}$  and  $\delta_{ijn}$  coefficients. The easiest way is probably to use the same weights for all characteristics, but satisfaction dimensions (e.g., playability) should have different mean and consequently different weight values for students and professors. Even the total effectiveness of the system should have different

weights with respect to students and professors as users of the system. Solution of the weights problem was the creation of a special questionnaire for all characteristics, dimensions and user weights where respondents (students and professors) assigned belief percentages concerning  $\gamma$ ,  $\theta$  and  $\delta$  variables.

## 5 Student testing for definition of weights

Questionnaire has been introduced to 98 students at University of Rijeka on June 11, 2008.

For satisfaction measures, the questionnaire entries were from 1 to 5, with 1 for *extremely unsatisfied* and 5 for *extremely satisfied*. For value measures, the questionnaire entries were from 1 for *not important* to 5 for *extremely important*.

The achieved results are shown in table 1.

An interesting results is represented by the fact that students' biggest value has been understandability, followed by usefulness, while the learning value is the smallest; calculating the  $\delta$  variable, there is only a 2% of difference.

### Value

	Mean	Variance	Std.Dev.	Standard Error	Kurtosis
Learning value	4,10	1,10	1,05	0,11	1,03
Content	4,24	0,54	0,73	0,07	-0,35
Perceived learning	4,13	0,90	0,95	0,10	1,47
Understandability	4,56	0,39	0,63	0,06	0,13
Usefulness	4,33	0,61	0,78	0,08	1,94

### Satisfaction

	Mean	Variance	Std.Dev.	Standard Error	Kurtosis
Experience	4,16	0,69	0,83	0,08	-0,77
Playability	4,26	0,62	0,79	0,08	0,30
Easy of Use	3,63	1,35	1,16	0,12	-0,74
Interface	3,73	0,79	0,89	0,09	-0,03

Table 1. Results of questionnaire for students

The calculation of the  $\delta$  variable is shown in table 2.

	Mean	$\delta$
Understandability,	4,55	0,21
Usefulness	4,33	0,20
Content	4,24	0,20
Perceived learning,	4,13	0,19
Learning value,	4,10	0,19
<b>Value Mean</b>	<b>4,27</b>	
	Mean	$\delta$
Experience	4,16	0,26
Playability	4,26	0,27
Easy of Use	3,63	0,23
Interface	3,73	0,24
<b>Satisfaction Mean</b>	<b>3,95</b>	

Table 2. Calculation of  $\delta$  variable

The weights  $\theta$  can thus be calculated and are 0,520 for value and 0,480 for satisfaction, indicating, somehow unexpectedly, that students give more credit to value of the learning system than on satisfaction of the system.

Questionnaire had also two additional questions regarding importance of professor and course in the mobile game-based learning system, and the obtained results are shown in table 3.

	Mean	Variance	Std.Dev.	Standard Error	Kurtosis
Professor	3,90	0,94	0,97	0,10	0,34
Course	3,92	0,90	0,95	0,10	0,39

Table 3. Additional questions regarding learning environment

This indicates that students take in account the course and professor. When results are transposed in percentages, there arises interesting result that students tie heavily professor and course with the system used for learning. Although nominal weight for professor is 77,96 %, and 78,37% for course, in mgbl analysis these data will not be used because of a lack of comparison between different courses and different professors using the mGBL games, and the ones using basic teaching methods.

## 6 Professor testing for definition of weights

Questionnaire has been used on a set of 18 professors and education professionals from different countries during the Cambridge conference “Serious Games on the move” on July 26, 2008. Questions were the same as for students with an additional question regarding weights, defining influence of the professors and student results on effectiveness of the system.

For satisfaction measures, the questionnaire entries were from 1 for *extremely unsatisfied* to 5 for *extremely satisfied*. For value measures, the questionnaire entries were 1 for *not important* to 5 for *extremely important*.

The obtained results are shown in table 4.

### Value

	Mean	Variance	Std.Dev.	Standard Error	Kurtosis
Learning value,	3,94	1,47	1,21	0,29	0,38
Content	3,89	1,05	1,02	0,24	-0,77
Perceived learning	4,06	0,88	0,94	0,22	-0,53
Understandability	4,17	0,62	0,79	0,19	-1,24
Usefulness	3,78	1,59	1,26	0,30	-0,21

### Satisfaction

	Mean	Variance	Std.Dev.	Standard Error	Kurtosis
Experience	4,056	0,88	0,94	0,22	-0,53
Playability	4,22	0,54	0,73	0,17	-0,91
Ease of Use	4,11	0,58	0,76	0,18	-1,12
Interface	3,44	1,08	1,04	0,25	-1,07

Table 4. Results of questionnaire for professors

Calculation of  $\delta$  variables is shown in table 5.

	Mean	$\delta$
Understandability,	4,17	0,21
Usefulness	3,78	0,19
Content	3,89	0,20
Perceived learning,	4,06	0,20
Learning value,	3,94	0,20
<b>Value Mean</b>	<b>3.97</b>	

	Mean	$\delta$
Experience	4,06	0,26
Playability	4,22	0,27
Easy of Use	4,11	0,26
Interface	3,44	0,22
<b>Satisfaction Mean</b>	<b>3.96</b>	

Table 5. Calculation of  $\delta$  variable

The  $\theta$  variable can also be calculated and it gives figures of 0,5005 for value and 0,4995 for satisfaction, indicating that professors give lightly more credit to value of the system then to user satisfaction.

Professors had additionally the task of determining variables defining the importance of perceived effectiveness respectively from students and professors in the total effectiveness value of the system. Results are shown in table 6 and define the  $\gamma$  values to be used in formula [1].

	Mean	Variance	Std.Dev.	Standard	Kurtosis
<b>Professors</b>	54,33	612,59	24,75	5,83	-0,75
<b>Students</b>	45,67	612,59	24,75	5,83	-0,75

Table 6. Factors defining importance of results from students and professors.

Results also show that professors differ quite widely in their perception of importance of student satisfaction as shown in picture 2, and taking in account that standard deviation of their responses is 24,75 %

As seen from table 6  $\gamma_{\text{professors}} = 54,33 \%$  and  $\gamma_{\text{students}} = 45,66\%$ .

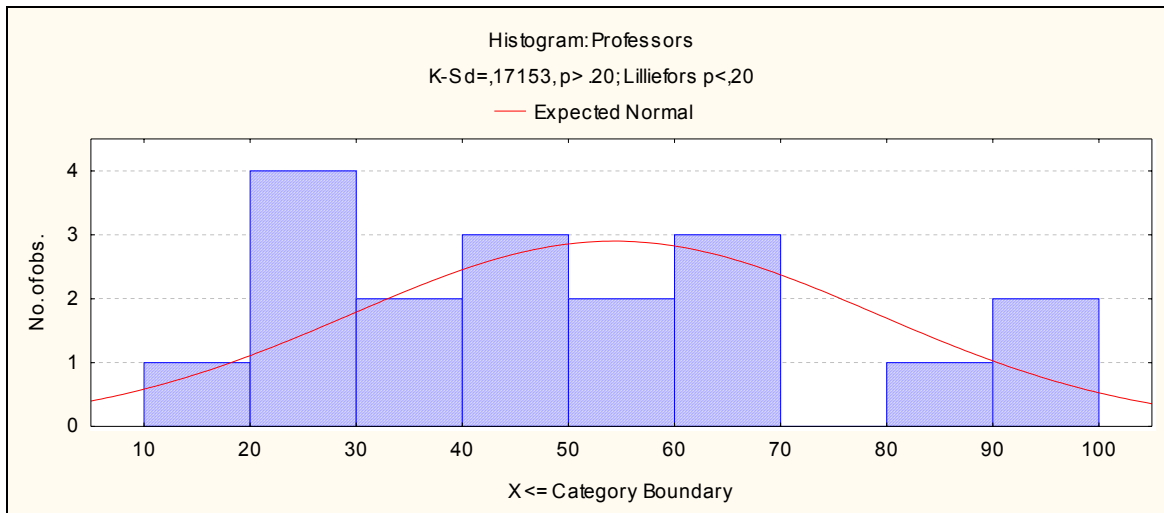


Figure 2. Histogram of the professor answers regarding importance of results from professors.

## 7 Students' user trials

Students' user trial has been conducted at the University of Rijeka, and has been presented in detail in 6.4 Final user trial report.

Summary of results of the students' user trials is shown in table 7.

	Mean	Variance	Std.Dev.	Standard	Kurtosis
<b>Game experience</b>	3,69	0,82	0,91	0,09	-0,17
<b>Contents</b>	3,80	0,52	0,72	0,07	-0,10
<b>Playability</b>	4,03	0,75	0,86	0,09	0,61
<b>Easiness of use</b>	4,34	0,66	0,82	0,08	-0,12
<b>Interface</b>	3,73	0,72	0,85	0,09	0,20
<b>Game Learning value</b>	3,96	0,56	0,75	0,08	-0,03
<b>Learnt using game</b>	3,96	0,49	0,70	0,07	-0,39
<b>Easiness of understanding</b>	4,31	0,55	0,74	0,08	0,46
<b>Usefulness</b>	4,05	0,65	0,81	0,08	-0,43
<b>Professor</b>	4,62	0,36	0,60	0,06	0,88
<b>Course</b>	4,41	0,54	0,73	0,07	3,63

Table 7. Students' user trial results

Students' perceived effectiveness can be calculated using the data computed in paragraph 3 and can be seen in table 8. Mean values for above answers are put into the correct place for evaluation of value or satisfaction characteristics. The third column ( $\delta$ ) shows the weights elaborated for the different characteristics. Fourth column (C) expresses the values (given as 1-5 range) as percentile values. Sum of weighted characteristics give values for the two Dimensions of the system: respectively of 80,43% of perceived value and 78,83 of perceived satisfaction. Weighting these values with the computed weights assigned for importance of the two dimensions gives the final result of 79,66 % of mGBL system effectiveness according to students' perceiving.

	Mean	$\delta$	C	$\delta\chi$	$\delta$	$\square$
Understandability,	4,31	0,21	86,19	18,37		
Usefulness	4,05	0,20	81,03	16,42		
Content	3,80	0,20	76,04	15,12		
Perceived learning,	3,96	0,19	79,16	15,32		
Learning value,	3,96	0,19	79,18	15,21		
Total				80,43	0,52	41.82
	Mean	$\delta$				
Experience	3,69	0,26	73,81	19,46		
Playability	4,03	0,27	80,62	21,74		
Easy of Use	4,34	0,23	86,80	19,97		
Interface	3,73	0,24	74,64	17,66		
Total				78,83		
<b>Student effectiveness</b>						<b>79,66</b>

Table 8. Calculation of student perceived effectiveness

## 8 Professors' user trials

Professors' user trials have been conducted at the University of Graz, at the University of Maribor and at the University of Rijeka, and have been presented in detail in 6.4 Final user trial report.

Summary of the results from professors' user trials are shown in table 9.

	Mean	Variance	Std.Dev.	Standard	Kurtosis
<b>Game experience</b>	3,71	1,24	1,11	0,42	-0,94
<b>Contents</b>	3,71	1,24	1,11	0,42	-0,94
<b>Playability</b>	3,00	1,33	1,15	0,44	-0,15
<b>Easy of use</b>	3,57	0,95	0,98	0,37	0,04
<b>Interface</b>	3,86	0,48	0,69	0,26	0,34
<b>Game Learning value</b>	3,57	0,95	0,98	0,37	0,04
<b>Learnt using game</b>	3,71	0,24	0,49	0,18	-0,84
<b>Easiness to understand</b>	3,71	1,24	1,11	0,42	-0,94
<b>Usefulness</b>	3,71	1,90	1,38	0,52	2,32

Table 9. Professors' user trial results

Professors perceived effectiveness can be calculated using the data computed in paragraph 4. The method is the same as above described for students' results and sums up to a perceived effectiveness for mGBL system by professors of 72,04 %.

	Mean	$\delta$	C	$\chi\delta$	$\delta$	$\square$
Understandability,	3,71	0,21	74,29	15,61		
Usefulness	3,71	0,19	74,29	14,15		
Content	3,71	0,20	74,29	14,57		
Perceived learning,	3,71	0,20	74,29	15,19		
Learning value,	3,57	0,20	71,43	14,21		
<b>Total</b>				73,72	0,50	36,90
	Mean	$\delta$				
Experience	3,71	0,26	74,29	19,03		
Playability	3,00	0,27	60,00	16,00		
Easy of Use	3,57	0,26	71,43	18,55		
Interface	3,86	0,22	77,14	16,78		
<b>Total</b>				70,36		
<b>Professor effectiveness</b>						72,04

Table 10. Calculation of student perceived effectiveness

## 9 Final calculation

In this report, a measure of the effectiveness of the mobile e-learning system is proposed. For the mGBL system it is shown that student perceived effectiveness is 79,66 %, and professors perceived effectiveness is 72,04%.

By using the results reported in table 6, where  $\gamma$  weights for importance of professors' and students' respective perceived effectiveness of the system were evaluated, we can compute the total effectiveness of mGBL system as follows:

$$Ef_{mgbl} = \sum_{i=1}^2 \gamma_i \sum_{j=1}^2 \theta_{ij} D_{ik} = \sum_{i=1}^2 \gamma_i \sum_{j=1}^2 \theta_{ij} \sum_{n=1}^m \delta_{ijn} C_{ijn}$$

$$Ef_{mgbl} = \gamma_{professors} * Ef_{professors} + \gamma_{students} * Ef_{students}$$

$$Ef_{mgbl} = 54,33 * 72,04 \% + 45,66 * 79,66 \% = 75,51 \%$$

Perceived effectiveness of mGBL system is thus evaluated at 75,51 %. This final aggregated value together with the separate values obtained for Value and Satisfaction towards mGBL system by part of both students and professors marks the mGBL system tested as a high effectiveness system according to the Learners' Value Index of Satisfaction (LeVIS).

## 10 Conclusion

The mGBL games were complex in terms of both pedagogy and organization. Their User Trials took place in different countries with players using different languages; in different schools with very different curricula; with students of different ages and varying skills and abilities; and with teachers with different experience, training and skills. Despite this, from the performed analysis it is clear that both teachers and students found them to be challenging and enjoyable experiences. Most important of all, there is clear evidence that significant learning took place and at least some of that learning was retained. Through the evaluations we have gathered, we have concluded the following key findings:

- The students learned
  - new facts across a range of curriculum subjects, as mGBL games can be cross-curricular;
  - new technology skills;
  - improved generic skills, especially teamwork and cooperation;
  - improved social skills, including self confidence.
- Teachers believe that games do allow them to achieve their intended learning outcomes.
- Students who do not respond well in the traditional classroom setting often emerged as positive and enthusiastic learners in the context of the games.
- It is critical to manage the amount of time which teachers have to devote to the development, customization and deployment of games if their potential for enhancing students' learning experiences are to be realized. mGBL used game templates but we believe that there is considerable scope for further developing this concept, providing a rich set of template resources into which teachers can drop their materials, assessments etc. Further research is needed to identify pedagogically-sound ways of

developing, sharing and exploiting structured templates, especially in the context of mobile devices.

- The issue of time also applies, but in a different way, to the deployment of this type of game. Time could not always be found during teaching hours to play the game. Embedding the game in the curriculum proved relatively easy for teachers, but embedding the game into the lessons timetable was not. Most games were special events. This is not necessarily a disadvantage, and indeed points to the need for schools and universities to become more flexible in their timetabling, seeing learning as a 'whole life' activity and giving credit for learning wherever it takes place.
- While there are great benefits to encouraging learning outside the walls of the school, we observed directly, and it was reported to us, that safety is a major issue. This is particularly the case where using small, portable devices with considerable resale value. If it becomes possible to make widespread use of 'everyday' mobile devices then it will be much easier to encourage such use. Thus technological development is likely to lead to greater learning opportunities – provided that students already have mobile devices of considerable power.
- It was clear from our observations and from the responses of teachers and students that they enjoyed playing the games and, as a result, were highly motivated both to participate and to complete their assignments.

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