Prototyping M-Learning Course on the Basis of Puzzle Learning Methodology

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Abstract. The aim of the "Puzzles for Nomad" project is to improve the system of education by filling gaps in job seekers' competencies in an informal way (incidental learning). That would enable graduates, especially of humanities, to adjust their skills to the needs of the modern workplace using an innovation teaching method based on puzzles (puzzle learning). The first stage of the project was to create and test a mobile prototype.

The distinctive, innovative features of our system are:

- puzzle learning – course contents follow the chosen methodology by integrating problem-based learning with the presentation (Presentation Practice Performance) methods, ensuring high levels of interaction with the user. The didactic process is carried in pre-planned stages or according to scenarios;
- learning outcomes ascribed to each stage, content is broken into stages of the learning process in accordance with the methodological approach;
- monitoring, testing, methodology and course organization are relevant to the pre-defined learning outcomes – we developed a procedure and a special qualifying questionnaire to check whether the expected learning objectives can be achieved and verified using our system of incidental learning;
- verification of the final product – a course developed by an expert is subject to review with respect to the criteria outlined in the correctness questionnaire at the methodological and technical levels;

All the elements described above form an adaptive system for incidental learning, which is innovative not only with regard to the problem it tackles (mechanisms for the adaptation of informal education to the current job market) but also forms of learner support (distance learning with the use of mobile devices adjusted to the needs and skills of learners), and target groups (learners and content providers, corporate users).

The system was based on the pilot course, a series of studies into the needs and opinions of users, and usability studies. These actions ensured high quality of user interface ergonomics in line with the rules of Human-Computer Interaction. Both the process of entering courses into the system and its use by students have been subject to in-depth usability tests.

The proposed system functionalities and the results of research, as well as the developed methodology, can be used to create similar m-learning systems.

Keywords: Methodologies for the study of computer supported collaborative learning and / or technology-enhanced learning, Mobile and/or ubiquitous learning, Open educational resources, Puzzle Learning, Nomad Education.

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1 Introduction

According to [2] m-learning (mobile learning) is a kind of e-learning which is based on the use of mobile devices (PDAs, mobile phones, notebooks or tablets) anywhere at any time. The progress made in these technologies in recent years has influenced everyday life [1,12] and the quality of distance learning [7]. These rapid changes inspired the authors to conduct research concerning the potential of m-learning in Poland. In the first part of this work we analysed whether Polish students were ready for joining m-learning courses. In the second part we investigated tuition-free online courses run in Polish as the language of instruction from the point of view of their relevance for the graduates of humanities. It turned out that all free m-learning courses [9] do not meet the requirements of either the methodology or multimedia quality of the courses. Following this observation a new methodology was proposed basing on [3,9] research. Next, we prepared a pilot course testing the proposed methodology. The obtained results showed that the proposed model meets the expectations of project beneficiaries, both from the point of view of methodology and organisation and presentation of materials.

2 Motivation and Background

According to the data published by the Ministry of Labour and Social Policy, job centres in Poland have observed an increase in the number of the unemployed with higher education diplomas – from nearly 4% in 2002 to 11.7% in 2012 (ca. 250 000 people). A quarter of the total number of unemployed persons are graduates of economy and administration, 15% of pedagogy and related fields, 14% of social sciences and 8% of humanities. In comparison – graduates of technical and engineering faculties account for only 8% of all university graduates. Another worrying phenomenon is the fact that many graduates accept job offers which are below their qualifications or in another field [13]

Young graduates exhibit high flexibility in terms of job seeking and the need to develop new skills. Focus group research involving 30 persons proved that the main motivator behind job change (taking a job other than the learned one) is the lack of opportunities to fulfill one's ambitions and no perspectives of further growth. Those data are consistent with the research done by the Public Opinion Research Centre in January 2013 (Occupational Mobility and Elasticity)

72 % of survey participants said they were ready to spend their free time improving their qualifications. A survey conducted as part of our project confirmed those findings. Our respondents admitted that they could devote 6.5 hours per week to learn new things (however there was a large standard deviation of 3.4). As far as preferred methods and organizational forms were concerned, most respondents pointed to individual learning (40%) conducted online (23%). In a study of older learners the percentages of participants of online courses was even higher (58%) with 78% assessing the content of e-learning courses well [8].

3 Analysis of the Popularity and Usage of Mobile Devices in Poland

Prior to launching the pilot course, a survey was conducted regarding the use of mobile devices among the user group. The results previously reported in [11] were compared with the data for the most popular mobile devices in Poland. A comparison was made in order to find out if similar devices are used by the selected target user group i.e. graduates of humanities.

In [11] it was reported on the use of mobile technologies in Poland and the Western World. The report also contained information regarding ways of creating multimedia elements for mobile devices, and ways in which users interact with them with a special emphasis on practices of User-Centered Design. A key difference between the project's target group and mobile users in Poland and the world in general is a smaller popularity of tablets. A total of 23 % respondents from the target group admitted to having owned a mobile phone for less than 6 months. Only 17% were planning to buy a new one in the near future. In the target group of 80 learners:

- 98% of respondents own a mobile phone
- 88% own a portable computer
- 10% own a tablet
- 58% had participated in e-learning courses before, and 78% of these described their attitude towards e-learning as positive
- 13% had participated in distance courses using mobile devices, and 55% of these described their attitude towards this type of content presentation as positive
- 70% watch films on their mobile phones
- 49% use their phone to acquire knowledge
- 24% are planning to buy a phone with the Android OS in the near future, and 7% with iOS
- 5% would not find time for mobile learning, 30% would spend about 30 minutes a day, 53% no more than 30-60 minutes, 10% 2-3 hours.

4 The Analysis of Resources of Online Courses Available in Polish

In order to assess the resource quality of free-of-charge distance learning courses, the resources were analysed and the following hypotheses verified: [9]

- There is a lack of clear and well-defined goals, following the recommendations of National Qualifications Framework;
- The content rage of offered courses is not large (a handful of subjects dominate);
- The presentation method is the most popular, interaction with a user is limited to summative assessment;
- Summative assessment does not allow for the reliable monitoring of the attainment of learning outcomes by a learner;

- Content featuring elements of mathematics and logic are not adjusted to meet the needs of our project's beneficiaries;
- Technical aspects of courses, including the multimedia, navigation and graphics of the user interface are often poor quality.

Resources which were analysed had to meet several criteria:

- They are public and easily accessible;
- They are free and require the maximum of free-of-charge user registration; free content is not limited to a demonstration (e.g. first lesson);
- They refer to the knowledge and skills relevant to the beneficiaries of the project as jobseekers [9]
- They are not limited to an e-book.

103 courses were examined, most of them available at http://kursolandia.pl, of which 61 were initially selected for further analysis. In the end the selection process identified 50 courses to be subject to further scrutiny.

Our research proved that currently available online courses are limited in scope, with many lacking any clearly defined learning objectives, which makes proper analysis impossible. Only a handful of courses have learning goals, but even then the type of final assessment used is inadequate. Courses often lack the definition of target audience, in which case it is difficult to say whether the methodology, forms and didactic means are relevant to the abilities and needs of our project beneficiaries. In all analysed courses the presentation mode dominated, and interactivity was limited to simple tasks done as part of ongoing assessment and closed questions which constituted final assessment. Some courses had nice-looking graphics but in most cases multimedia elements were irrelevant and served aesthetic rather than didactic purposes.

Furthermore, some materials were published in the e-book format and presented as online courses, which might be misleading for a user and lead to negative opinions about e-learning. On the other hand, solutions which seem fine from the methodological point of view, such as PARP Academy, are not aimed at the beneficiaries of our project.

To sum up, the analysis showed that the current offer of free-of-charge distance (online) courses does not provide our project beneficiaries with opportunities to adjust their competencies to the needs with the Polish job market [9].

Our analyses led to conclusions that the most important features of a system meant for incidental learning of our target group, i.e. the graduates of humanities, should be the following:

- Conformance to the fundamental rules of education, including the need for acquired knowledge to be operative and practical, the need for high interactivity (learner activity), appeal to many senses, individualisation, differentiation of methods and assessment forms;

- relevance of content in relations to the needs of the job market and integration of final (summative) assessment with a system for the management of competencies;
- agreement of course objectives with the National Qualifications Framework;
- use of methods, forms and means appropriate to the needs, abilities and preferences of learners (e.g. it is advisable to incorporate elements of learner participation and cooperation).

5 Methodology Based on Elements of Puzzle-Learning

Puzzle Learning is a new teaching and learning methodology focused on solving different kinds of problems using puzzles [3,4]. It is possible to increase the student's mathematical awareness and problem solving skills by discussing a variety of puzzles. Such a methodological approach relies on standards requiring from a teacher to define a problem, present a puzzle to illustrate it, in order for the learner to see the complexity of the problem in question. Then the teacher lets the learners deal with the puzzle, providing feedback whenever necessary. At the next stage, the teacher explains the theoretical background related to the problem and checks the skills mastered by the students. The initial program is followed by subsequent presentation of the wider context of the problem and, finally, final assessment of the predefined learning outcomes [6]. This methodology allows students to take an active part in solving tasks and thus promotes better understanding of the presented issues. Students can use these methods for solving problems in different fields. It is the opposite of passive approach to studying, like reading without understanding and rote learning of ready-made solutions.[5]

The three basic rules of Puzzle-Learning are:

- Rule 1. Make sure you understand the problem and all key terms used to define it.
- Rule 2. Do not trust intuition; calculations are more reliable.
- Rule 3. Calculations and reasoning will be more constructive if you create a model for the given problem, defining its variables, limitations and objectives. [3]

Below we present an example of a puzzle used in the course.

General teaching aim of the puzzle:

- To develop problem-solving skills.

Learning outcomes:

- Knowledge: the user defines the sense (rationale) of defining assessment criteria in situations where problems are not adequately defined.

Puzzle 1 (Fig.1.):

- You have two sand timers – a 2-minute and a 5-minute one. You want to have soft-boiled eggs and you prefer eggs boiled for 3 minutes. How can you do this using the two devices described above?

Ongoing monitoring:

- A user should have the opportunity of using the sand timers, one at a time and simultaneously. When a sand timer's top bulb is empty, the user should have the opportunity of throwing an egg into the water.

Correct answer:

- The best way is to use both sand timers simultaneously. When the 2-minute one is empty, there will be enough sand for the next 3 minutes in the other one; therefore it is the right time to throw in the eggs.

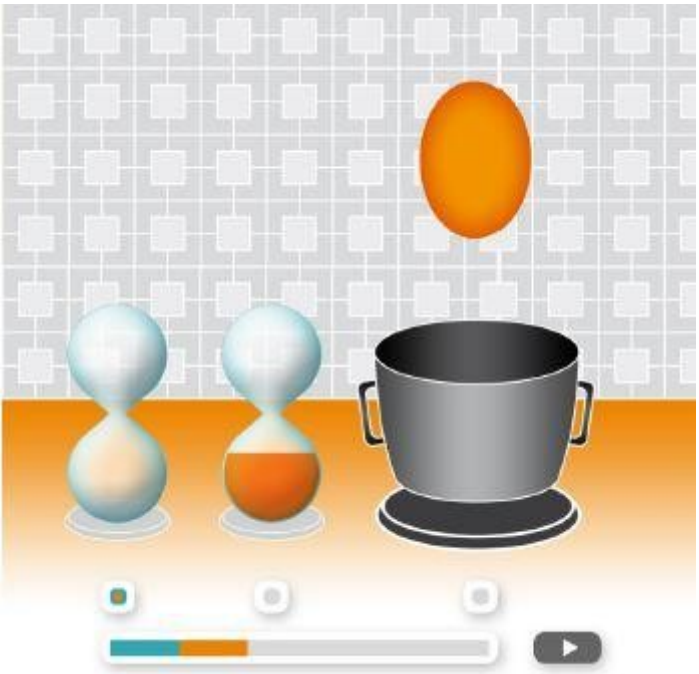

Fig. 1. The graphic presentation of the described puzzle

Basing on the above methodology used in the pilot course, we broke the teaching/learning process into stages presented in the table.

Table 1. Stages of the didactic process of the pilot course

Stage	Actions	
Introduction	Stage 1	• Choosing learning outcomes • Explaining the subject of the lesson (unit) • Shaping a learner's motivation
Problem/puzzle	Stage 2	• presentation of the problem or puzzle illustrating the given problem
	Stage 3	• providing the learner with an opportunity of solving the problem/puzzle (providing tips)
	Stage 4	• providing the learner with feedback
	Stage 5	• presenting lesson goals (the problem illustrated by the puzzle)
Knowledge	Stage 6	• presentation of the knowledge related to the chosen subject
Skills	Stage 7	• testing of acquired knowledge and the ability to apply it in practice (ongoing assessment) • tips for further learning
Consolidation	Stage 8	• presenting a broader perspective • generalisation of the learnt material more examples
Summary	Stage 9	• presenting the importance of the gained knowledge and skills
Final verification (testing)	Stage 10	• verification if the goals of the lesson have been attained.

In order to prepare a course using the puzzle-learning method, it is necessary to use the course template. That forces a user to follow a set sequence of course design and development stages:

- Formulate the expected outcomes
- Find out who the learners are, what are their cognitive skills and personality traits
- Define what knowledge, skills and social competencies are necessary to reach the learning goals
- Set detailed, measurable, realistic and observable learning outcomes
- Develop monitoring tools, such as tests checking whether concrete outcomes have been reached
- Pick teaching/learning strategy, decide whether to use presentation mode or searching mode with the elements of puzzle learning
- Fill-in a qualifying questionnaire and a questionnaire which will be the basis for course approval at the concept stage. Both questionnaires are verified by a methodology specialist.
- Prepare a scenario and multimedia. Fig. 2 presents a template of a scenario divided into screens, with learning outcomes, core and optional multimedia and navigation.

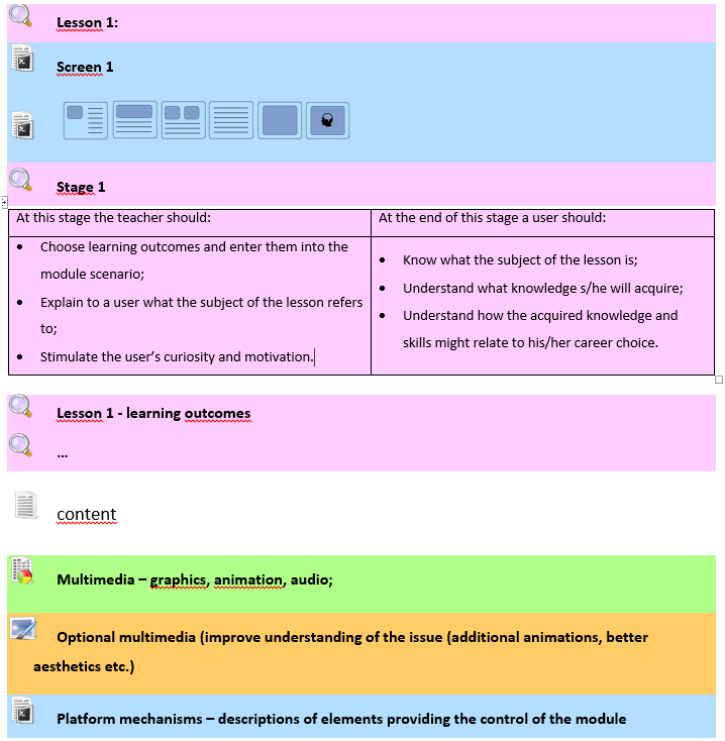

Fig. 2. Template of a scenario

When filled-in this template allows for a course to be entered into its mobile version.

6 Construction of the First Mobile Version of the Pilot Course

It was decided that the course should run on mobile devices because that was consistent with the character of the project, i.e. Nomadic Learning. Research was carried into the preferred resolutions of audio, video, static graphics and animations. Then decisions regarding the technology utilised in the pilot study were based on the devices and multimedia formats favored by the target group. Currently one of the most frequently used solutions for developing content for multiple mobile platforms is HTML5 combined with CSS3 and JavaScript, whose operation is actively supported by the latest mobile web browsers. That ensures similar display of content and consistent interaction on many platforms without additional effort. jQuery Mobile is a very popular free-of-charge solution offering predefined graphic and interaction components (widgets). The pilot course was developed using this particular technology.

The course uses a minimalist user interface which allows for simple transitions between screens with the help of large, easily visible buttons. Interactivity is provided by means of timed quizzes, illustrations appearing upon clicking and audio/video players. Course scenario depends on previous answers, which are remembered by the application.

The course uses the Responsive Web Design technology, which helps adjust the content to mobile device screens of different sizes. Below we present screenshots from the mobile version of the course on the examples of a smartphone (Fig.3.) and a tablet (Fig.4.).

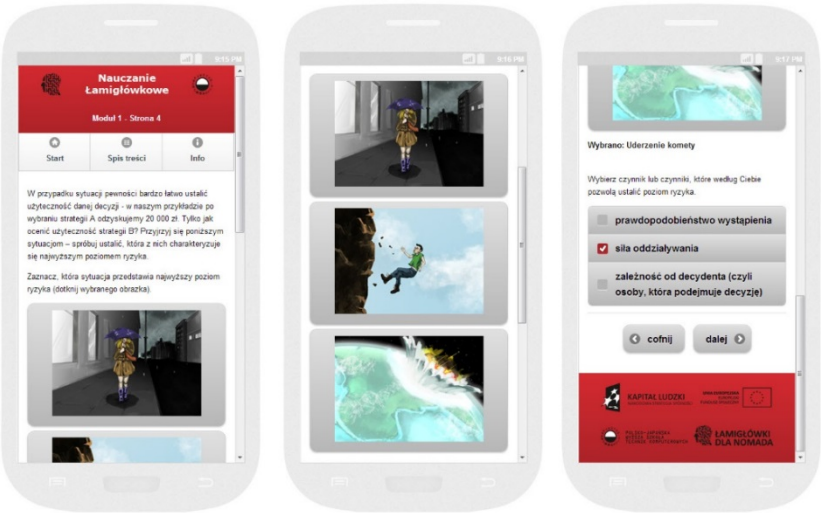

Fig. 3. Mobile version of the course on smartphone

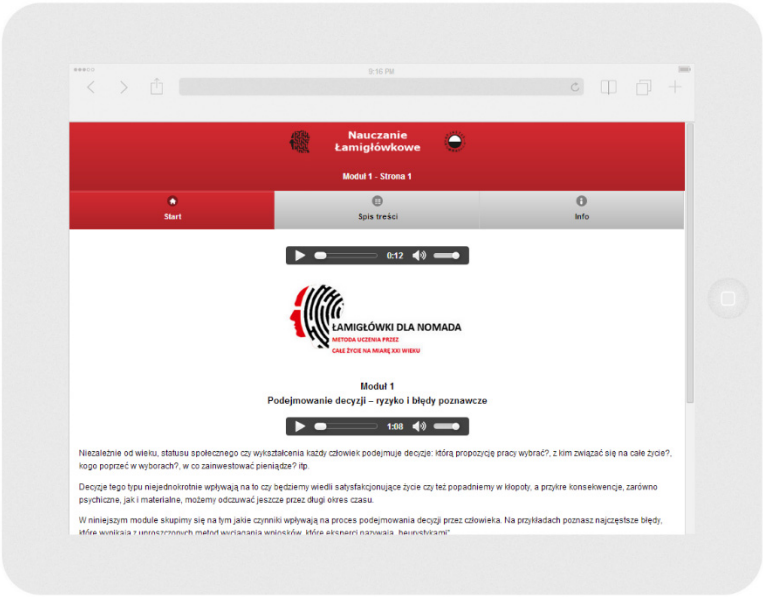

Fig. 4. Mobile version of the course on tablet

7 Evaluation of the Pilot Course

In the last stage of our research we set out to verify our hypotheses. The results confirm that the incidental-learning model allows to attain educational goals, however the effectiveness of the learning process depends on many factors – didactic, technical and pertaining to the attitudes of learners, as well as their self-study competencies. Our results suggest that it is easier to reach an objective related to the area of 'application' rather than 'knowledge', the most difficult being 'comprehension'. To confirm the observations more extensive research needs to be conducted.

In some cases negative effectiveness of learning was observed, which, together with data on self-regulation of the learning and assessment processes (e.g. the time between starting a course and attempting a final test), casts doubt on whether the failing participants took their learning seriously. Disregarding those data, however, could adversely affect the reliability of results because with the single-choice questions, from the point of view of statistics, the number of chance incorrect hits should equal the number of correct answers [10].

Despite the above-mentioned limitations, the results allow us to conclude that the proposed model meets the needs of the students from both perspectives - methodology and structure. Research results serve as guidelines to be used in the further stages of the project, i.e. work on a number of new courses.

On the basis of obtained results, the following recommendations have been formulated for the authors of methodology books, courses, and for the teachers:

- content should be broken into small 15-45-minute thematic blocks (lessons) which would focus on a very limited (one to three) detailed operating objectives;
- a screen should not contain too much text;
- problems discussed should be illustrated with examples and multimedia elements, especially if they refer to abstract-symbolic explanations;
- the didactic process should combine the stages of problem-solving with presentation, in order to balance theory with its practical applications;
- the didactic process should incorporate interactivity and tests verifying content comprehension and skills acquisition (ongoing assessment);
- testing questions should contain clear explanation of assessment criteria, especially in the case of open questions (final assessment).

8 Future Work

Currently we are working on the development and implementation of a full e-learning platform and an m-learning platform which will base on previous assumptions and the results of the pilot test. The e-learning platform will feature an extended module for lecturers/editors allowing for the easy publication of courses and accompanying materials on the platform. We envisage the option of creating moderated courses (i.e. with a lecturer) in a distance and blended models, as well as non-moderated ones (without a lecturer/moderator). The platform will enable the creation of a course structure with the use of ready-made templates and designing a unique structure with the help of a drag&drop menu. We plan to give course authors access to a puzzle editor so that they could add more advanced logical tasks. Below we present first models of the platform showing selected functionalities.

Both the e-learning and the m-learning platforms will be subject to detailed evaluation whose aim is the analysis of the usability of applied user-interface solutions. That will help identify main problems which users might encounter while working with the platform and propose solutions which should enhance the ergonomic quality of the analysed interfaces.

Usability testing will be carried in controlled conditions at PJIIT, where individual users will be observed by a moderator/researcher while doing pre-defined tasks. User interactions and actions will be registered by a program recording screen content in a video form. Those recordings will be subject to further analysis. Users will also be encouraged to share their remarks regarding the tested platform ("Thinking Aloud Protocol"), which will also be recorded. After the usability test, the user will complete a satisfaction questionnaire to express his/her opinions on working with the platform. The research will be followed by a final report describing the usability tests with the lists of the problems that emerged, organised according to predefined priorities and illustrated with relevant screenshots, user comments, questionnaire results as well as their interpretation.

Regular usability tests will enable platform modification, which should help maintain its high reliability and ease-of-use both for students and teachers.

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