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RESEARCH ON TABLETS APPLICATION FOR MOBILE LEARNING ACTIVITIES

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The paper aims to present current research on application of tablet devices for mobile learning activities in Europe. The quality of modern learner centred mobile learning activities based on learning personalisation, problem solving, collaboration, content creation, and flipped classroom methods is compared against the quality of traditional teacher centred learning activities based on knowledge transmission usually applied at schools at the moment. Tablet devices and web applications are the main technologies used in presented mobile learning activities. Flagship EU-funded projects in the area – iTEC and CCL – are presented in the paper. Systematic review results on tablets use in education and personalisation of learning are also provided in the paper. Method of expert evaluation of learning activities based on multiple criteria decision analysis and Fuzzy methods as well as its application in CCL project are presented in more detail. A special attention is paid to suitability of mobile learning activities to particular learning styles. An example of interconnection between students learning styles, suitable learning activities, tablet apps and learning objects types is provided in the paper. Solution of learning activities quality evaluation and optimisation problem could help teachers to select suitable learning activities for particular learning styles. Research results have shown that the proposed Fuzzy method is quite objective, exact and simple to use for selecting qualitative learning activities for particular learning styles.

Key words: Mobile learning activities, tablets, quality criteria, expert evaluation

1 Introduction

The paper aims to present current research on using tablets to pilot mobile learning activities (LA) in primary and secondary education in Europe.

Many of the older definitions of mobile learning are either focused on the learner being mobile or narrowly focused on the device and technology [23]. ADL [1] describes mobile learning as: “Leveraging ubiquitous mobile technology for the adoption or augmentation of knowledge, behaviours, or skills through education, training, or performance support while the mobility of the learner may be independent of time, location, and space.”

According to [23], mobile learning presents new opportunities for both the design and delivery of learning. These opportunities are enabled by the unique hardware and software capabilities of mobile devices (such as tablets) coupled with convenient size and portability. Touchscreen tablets allow a human finger or stylus to be used for interacting with the device. Among all mobile devices (smartphones, e-readers, basic mobile phones, non-phone devices etc.), tablets are mostly used in learning at the moment – 61% [23].

In the paper, the quality of learner centred mobile LA using tablets based on learning personalisation, problem solving, Web 2.0 enhanced collaboration, content creation, and flipped classroom methods are compared against the quality of traditional teacher centred LA based on knowledge transmission usually applied at primary and secondary schools at the moment.

Method of expert evaluation of LA based on multiple criteria decision analysis and Fuzzy methods as well as its application in CCL [5] project are presented in more detail.

Currently, LA for primary and secondary education are deeply analysed, applied, and evaluated in EU flagship projects iTEC [13] and CCL [5]. Therefore, these flagship EU-funded projects in the area are also presented further in the paper.

2 Current Research and Practice

In this section, we briefly explore the related projects and provide systematic review of scientific literature in the area.

2.1 Related Projects

iTEC (Innovative Technologies for Engaging Classrooms) [13] is a major EU-funded project in which European education ministries, technology providers and research organisations are working together to bring about transformation in learning and teaching through the strategic application of learning technology. With 27 project partners, including 15 Ministries of Education, and funding of €9.45 million from the European Commission’s FP7 programme, iTEC is the largest and most strategic project that has the potential to be a flagship project for the design of the future classroom. The project brings together teachers, policymakers, pedagogical experts – representatives from each stage of the educational processes – to introduce innovative teaching practices. Future classroom’s LA created in iTEC are piloted and validated in over 2,000 classrooms all over Europe.

The Creative Classrooms Lab (CCL) [5] project is developing innovative teaching and learning activities involving the use of tablets in and out of school. It validates these in policy experimentations involving 9 Ministries of Education in Europe and 45 classes that are already making use of tablets from different suppliers. Ministries of Education also seek to co-design action research pilots with industry partners that are project Associate Partners. CCL is one of the means to help European Ministries of Education to make proper decisions concerning large scale investments in tablet devices and related teacher training.

According to [17], the core topics identified for CCL implementation are:

1. Personalisation: e.g. where the project explores how technology-based learning resources can be organised and modified to overcome learning barriers for individual learners and maximise their learning outcomes
2. Content creation: e.g. where the project explores how teachers and learners have migrated from consumers of content to creators, including apps, multi-media and other formats

3. Flipped Classroom: e.g. where direct instruction is delivered outside the group learning space/classroom and teachers then use in-class time to actively engage students in the learning process and provide them with personalised support. This approach can be a powerful element of a Personalisation strategy
4. Collaborative Work: e.g. where the project explores how collaborative learning involves two or more people co-operating in a learning experience to share and contribute to each member's understanding of a topic and to complete a given task

In CCL, all learning activities selected for piloting in different countries are based on problem solving (or problem based learning) method.

The author of the paper is Lithuanian project manager in iTEC [13] and CCL [5].

2.2 Systematic Review of Scientific Literature

According to [17], there is relatively little academic research on the use of tablet computers in education. There is however a lot of observational evidence on the impact of tablet technologies on engagement, concentration, motivation, behaviour, self-directed learning and collaborative behaviour.

We performed Systematic review of scientific literature in ISI Web of Science database in August 2013. Topics selected for Systematic review were as follows: ” ’tablet devices’ and ‘education’ ” (33 references found incl. 12 Articles and 21 Proceedings papers), and ” ’information technologies’ and ‘personalisation’ ” (69 references found incl. 27 Articles and 42 Proceedings papers).

The Systematic review on ” ’tablet devices’ and ‘education’ ” has shown that tablet devices could have a positive impact on students’ learning outcomes and motivation. The main challenge here is a proper implementation of suitable teaching / learning methods and activities.

Morris et al. [22] conclude that undergraduate science students can make extensive use of a tablet device to enhance their learning opportunities without institutions changing their teaching methods or computer systems, but that institutional intervention may be needed to drive changes in student behaviour toward the use of novel Web 2.0.

According to [24], today’s teachers might prefer tablet personal computers (PCs) over desktop or laptop computers to structure interactive, engaging learning experiences. Given the central role of teaching practice in learning outcomes, advances in the use of tablets in education will be driven not primarily by technology features but rather by instructional models that reflective educators develop and share with their peers.

Sommerich et al. [26] present findings of a study of high school students participating in a tablet PC programme. Primary areas of interest were students’ experiences with and attitudes about the tablet PCs, physical discomfort associated with use of tablets and temporal and task-driven patterns of tablets use. Data were collected via questionnaire and computer use monitoring software. Results showed students’ attitudes were generally quite positive towards the tablets, although they did not tend to think tablet PCs had improved their grades, few disagreed that tablets were a distraction in class, and visual and musculoskeletal discomfort was prevalent. Understanding how to use the tablets and recognizing its organizational capacity were associated with several positive attitudes towards the tablets, including making school more enjoyable. Children’s exposure to computers will only increase, so study of the many dimensions of their impact is critical in order to understand what is effective, constructive and healthful for children.

According to [21], the tablet PC is an attractive technology for use in synchronous distributed learning environments because of its mobility, and its ability to not only serve as an effective note taking device but also as a high-resolution course content viewing device and a tool for interactive assessments.

In [2], assessment results revealed that the implementation of tablet PC based collaborative project-based learning had brought transformational changes to the traditional engineering classrooms to support student centred learning. The paper also describes the impact of tablet PC based teaching strategy on lecture styles, teaching effectiveness and student learning outcomes from both the faculty and students' perspectives.

[4], reporting on the results of preliminary research and use, focuses on mobile wireless and 'inking' technology such as tablet PCs as a more effective way of achieving learning and assessment outcomes, than more 'conventional ways'. As well as bringing the classroom 'to life', the technology itself offers a 'new way' to enhance student learning and assessment. The results show a dramatic increase in learning and assessment results, compared to more conventional methods as well as the added benefits of increased student attendance and overall subject 'interest'.

[27] results indicate that the tablet PC-based instruction had the greatest impact on the students in the bottom half of the class.

Enriquez et al. [9] demonstrate how innovative use of tablet PCs has enabled new approaches to collaboration and real-time feedback, improving student achievement and engagement.

According to [20], the device that provides us the contents determines the manner in which our brain learns. Also, another very important key fact is that the user interface has been altered. In the case of tablets, the typical mouse and keyboard has been replaced by a touch screen. Depending on our student's profile, the touch screen will present a set of advantages (or disadvantages).

According to [11], one of the potential usages of tablet computer is in education where it has the potential to replace textbook and provide essential tools for learning. It opens up new and exciting methods of delivering knowledge to the student. Although tablet computer is a powerful hardware supported by thousands of applications and games, the implementation readiness of the device is crucial when considering for reliable use of tablet computers in classroom environment. Thus, [11] attempts to discuss issues related to tablet computer implementation readiness for classroom use in term of hardware, cost, software, digital content, infrastructure and security. The potential issues highlighted might hinder the potential of tablet computer to be successfully implemented in classroom environment.

The most important finding of [25] is that students who began their undergraduate mathematics education in tablet PC classes were more likely to continue their science and engineering studies than were their peers who took non-tablet PC courses during their first semester of college.

The Systematic review on " 'information technologies' and 'personalisation' " has shown that information technologies (incl. tablets) could have a positive impact on learning personalisation and thus on learning results, but their additive value highly depends on proper application of suitable learning activities.

According to numerous scientific research results ([3], [8], [19]), personalised student centred learning approach is much more effective in comparison with traditional teacher centred ”one size fits all” approach usually applied at schools currently.

Vasilleva [28] think that we are teaching a new generation of students who have been cradled in technologies, communication, and an abundance of information. As a result, the design of learning technologies needs to focus on supporting social learning in context. Instead of designing technologies that ”teach” the learner, the new social learning technologies will perform three main roles: (1) support the learner in finding the right content (right for the context, particular learner, specific purpose of the learner, and pedagogically), (2) support learners to connect with the right people (right for the context, learner, purpose, educational goal, etc.), and (3) motivate / incentivize people to learn.

Graf et al. [10] consider that to provide personalisation and adaptivity in technology enhanced learning systems, the needs of learners have to be known by the system first.

According to Lazarinis et al. [16], personalisation is based on the characteristics of the individual learners, and learner profiles can be elicited and presented to educators to help them understand their learners.

Chang and Chen [6] think that recent advances in information and communication technologies, especially web technology, mean not only that e-learning is unlimited in location of computers, but also that learners can study in the virtual learning environment. This situation may present some problems, such as social skills, personalisation / individualisation, self-regulated learning skills and communication problem.

According to Chen et al. [7], to provide users with more suitable and personalised service, personalisation is widely used in various fields. [7] defined the concept and characteristic of the personalised learning service, and proposed a semantic learning service personalised framework.

Wang and Huang [29] think that there has been a growing awareness that courseware should automatically adjust to the profiles of individual learners.

According to IMS LD [12], learning activities are one of the core structural elements of the ‘learning workflow’ model for learning design. They form the link between the roles and the learning objects (LOs) and services in the learning environment. LO is referred here as any digital resource that can be reused to support learning [30]. The activities describe a role they have to undertake within a specified environment composed of LOs and services. Activities take place in a so-called ‘environment’, which is a structured collection of LOs, services, and sub-environments.

3 Research Approach

3.1 Mobile Learning Activities in CCL

In CCL [5], we have prepared a number of typical problem solving sets of activities (i.e. scenarios) based on personalised learning approach using Web 2.0 based group work, content creation, and flipped classroom methods for piloting in Lithuanian CCL schools.

Problem solving scenario should be implemented by the following steps:

(1) Discussing the problem scenario in the groups which promotes communication skills and cooperative learning

(2) Brainstorming ideas to cross the learning boundaries which promote creative learning and knowledge integration

(3) Identifying the learning issues for research which promotes active learning and critical thinking

(4) Research to construct the action plans which promotes new knowledge development

(5) Reporting the research findings to the groups which promotes peer-to-peer learning to complete the final products.

Personalised learning approach is implemented here by division of learners into distinct groups according to their learning styles. We use learning styles (or preferences) grouping method applied earlier in [15], namely, Activist, Theorist, Pragmatist, and Reflector:

(1) Activists learn by doing; their preferred activities are: brainstorming, problem solving, group discussion, puzzles, competitions, and role-play

(2) Reflectors learn by observing and thinking about what happened; their preferred activities are: paired discussions, self-analysis questionnaires, personality questionnaires, time out, observing activities, feedback from others, coaching, and interviews

(3) Pragmatists need to be able to see how to put the learning into practice in the real world; their preferred activities are: time to think about how to apply learning in reality, case studies, problem solving, and discussion

(4) Theorists like to understand the theory behind the actions; their preferred activities are: models, statistics, stories, quotes, background information, and applying theories.

There are different methods to determine students' learning styles, e.g. questionnaires, learners' interviews, analysis of their e-portfolios, data mining etc. In CCL [5], we have developed e-questionnaire and software to automatically establishing students' learning styles.

Its application in Lithuanian CCL schools has shown that there are almost no 'pure' Activists, Reflectors, Pragmatists or Theorists in real life – students are mostly "mixtures" of different learning styles. In CCL [5], we use questionnaire based software designed for teachers to get full information on students' learning styles.

Students' learning styles are interconnected with suitable learning activities, types of LOs, and tablets' apps. Therefore, in personalised LA, learners should be divided into distinct groups according to their learning styles before or just after Discussion stage of the problem solving activity. This could guarantee that, in their groups, learners could learn using suitable LAs, LOs, and apps.

An example of interconnecting Brainstorming learning activity with suitable tablet apps and learning objects types in provided in Table 1. Brainstorming learning activity was aforementioned as preferred learning ativity for Activists.

In Table 1, apps are provided both working in IOS (iPads) and Android (e.g. Samsung) operating systems. LOs types are provided by the European LRE LOs types Vocabulary [18].

Table 1 Interconnection of Activists Brainstorming learning activity with suitable apps and LOs types

IOS	Android	IOS/Android	Types of LOs
Idea Sketch – lets you easily draw a diagram – mind map, concept map, or flow chart - and convert it to a text outline, and vice versa. You can use Idea Sketch for anything, such as brainstorming new ideas, illustrating concepts, making lists and outlines, planning presentations, creating organizational charts, and more!	**Mindjet for Android** – rated as one of the best mind mapping apps for Android. Create nodes and notes, add images of your own or icons provided, and add attachments and hyperlinks. Sync to your Dropbox	**Mind Mapping** – lets you create, view and edit mind maps online or offline and lets the app synch with your online account whenever connected. You can share mind maps directly from the device, inviting users via email. You can add icons, colours and styles, view notes, links and tasks and apply map themes, drag and drop and zoom	Application, Broadcast, Enquiry-oriented activity, Glossary, Open activity, Presentation, Reference, Role play, Simulation, Tool, Website

Learners could be divided into groups according to their learning styles e.g. applying Web 2.0 tools such as TeamUp grouping tool created in [13]. Collaboration in groups could be based on face-to-face collaboration and Web 2.0 tools. Groups' internal collaboration activities could be applied in Brainstorming, Identifying the research issues, and Research steps, and could be combined with the other groups in Discussion and Reporting steps of the problem solving LA.

The flipped classroom is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions. The value of a flipped classroom is in the repurposing of class time into a workshop where students can inquire about lecture content, test their skills in applying knowledge, and interact with one another in hands-on activities. During class sessions, instructors function as coaches or advisors, encouraging students in individual inquiry and collaborative effort. Flipped classroom activities could be applied in Brainstorming, Identifying the research issues, and Research steps of the problem solving LA.

In CCL [5], we have proposed mobile personalised learner centred LA on problem solving named "Why ships don't sink", or simply LA_1. LA_1 conforms to 10-lessons Lithuanian Physics curriculum topic on the Archimedes law. In this mobile LA, students use tablets in all stages of their problem solving activity for grouping, research, collaboration, flipping, content creation, and presenting their research results to peers and teacher. In LA_1, students use personalised learning methods, suitable content and apps while working with IOS (iPads) and Android (Samsung tablets) operating systems. There are several outdoor activities envisaged in LA_1 such as visiting sea museum, homework etc.

On contrary to LA_1, we consider LA_2 as traditional teacher centred "one size fits all" activity based on knowledge transmission. Several years' Lithuanian experience has shown that using tablets for traditional teacher centred LA_2 based learning does not lead to better learning outcomes.

3.2 Learning Activity Quality Criteria

In this research, different LAs use the same learning topics of Lithuanian Physics curriculum.

Here we use LA quality criteria that were elaborated earlier in [15] while implementing [13]. These LA quality criteria are presented in Fig. 1.

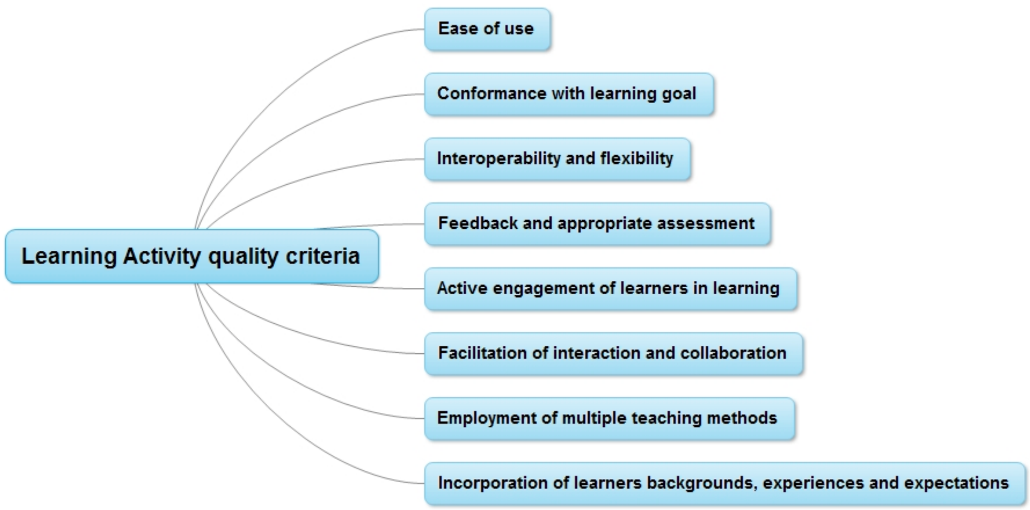

Figure 1 Learning activity quality criteria [15]

We see that LAs alternatives have a number of quality criteria. These criteria are often conflicting. Some LA could be of excellent quality against the particular criteria, and poor – against the other ones, and vice versa. Therefore, evaluation of the LA quality is a typical case where multiple criteria decision analysis (MCDA) approach should be applied. Therefore, in order to evaluate and compare the quality of LAs alternatives LA_1 and LA_2, we should apply multiple criteria decision analysis approach and some scientific methods suitable to evaluate and compare many alternatives.

3.3 Multiple Criteria Decision Analysis and Fuzzy Methods

In CCL, bottom-up (i.e. users centred) LA evaluation approach based on teachers and students questionnaires will be applied after piloting scenarios in schools in winter 2013–2014.

In the paper, we apply so-called top-down (i.e. expert evaluation) approach based on MCDA [14]. According to the top-down MCDA based approach, LA should be evaluated against a number of the quality criteria by experts-evaluators. The results of this top-down evaluation will be compared later with the results of bottom-up evaluation in CCL. LA multiple criteria evaluation method used by the authors is referred here as the experts' additive utility function represented by formula (1) including LA quality criteria, their ratings (values) and weights as follows:

$$f(X) = \sum_{i=1}^{m} a_i f_i(X), \quad \sum_{i=1}^{m} a_i = 1, \quad a_i > 0 \qquad (1)$$

Here $f_i(X)$ is the rating (value) of the criterion i for the each of the examined LA alternatives X, and the weights a_i are normalised according to the normalisation requirement (the sum is equal 1) in order to obtain the final results expressed in per cents. The major is the meaning of the utility function (1) the better is LA alternative.

According to [14], conversion linguistic variables "excellent", "good", "fair", "poor", and "bad" into triangular Fuzzy numbers to establish numerical ratings (values) of the quality criteria should be as follows: excellent – 0.850; good – 0.675; fair – 0.500; poor – 0.325; bad – 0.150.

In the paper, we invited three experts-evaluators from CCL project.

They considered all criteria equally important. Therefore, all the weights according to normalisation requirement should be equal 0.125. In the case when the experts consider that LA quality criteria should be of different importance, they could use Fuzzy based weights establishing method proposed by [14]. The method is as follows: if an expert evaluator establishes a weight of the criteria *i* in a form of a linguistic variable, we can convert it into the triangular Fuzzy number m_f^i .

According to [14], if we have *t* experts we can calculate it using the experts' average (2):

$$m_j^i = \frac{1}{t}\sum_{k=1}^{t} m_k^i \tag{2}$$

If we want to normalise the weights of the quality criteria, we should apply formula (3):

$$a_i = \frac{m_j^i}{\sum_{s=1}^{m} m_f^s} \tag{3}$$

4 Experimental Research Results

Let us evaluate each of two LA alternatives (i.e. mobile student centred LA_1 and traditional teacher centred LA_2) according to each of the quality criteria presented in Fig. 1 using triangular Fuzzy numbers presented earlier in Section 3.3. The following evaluation results were obtained by applying formula (1):

$$LA_1: 0.125 * (0.675 + 0.850 + 0.850 + 0.850 + 0.850 + 0.850 + 0.850 + 0.850) = 0.828 \tag{4}$$

$$LA_2: 0.125 * (0.850 + 0.850 + 0.500 + 0.500 + 0.325 + 0.325 + 0.500 + 0.150) = 0.500 \tag{5}$$

The evaluation results are based on the experts' assumption that both LA alternatives are applied properly. Evaluators consider that traditional teacher centred LA_2 is easier to use than mobile student centred LA_1, and both LA equally conform to the learning goal. According to the other quality criteria (Fig. 1), LA_1 is of higher quality than LA_2. It is obvious that mobile student centred LA_1 is more flexible than traditional teacher centred LA_2, it has more possibilities for feedback, it more actively engages students in learning, it facilitates interaction and collaboration, it employs multiple teaching and learning methods (problem solving, personalisation, collaboration, content creation, flipped classroom), and incorporates learners' backgrounds, experiences and expectations by applying students' grouping according to their learning styles.

These results mean that LA_1 is almost 33% better than LA_2 (82.8% Vs 50.0%). Therefore, the quality of LA_1 is near "excellent", and the quality of LA_2 is "fair".

On CCL experts' opinion, LA_1 based mobile learning activities using tablets could have a noticeable additive value for Activists and Pragmatists, and they could be also useful for Reflectors, but they have only minor additive value for Theorists. Since Activists learn by doing and their preferred activities are brainstorming, problem solving, group discussion, puzzles, competitions, and role-play, mobile learning activities based on problem solving, personalisation, collaboration, content creation, and flipped classroom should be very valuable for them. The same is true for Pragmatists since they need to be able to see how to put the learning into practice in the real world. Mobile student centred LA are less valuable for Reflectors since their preferred activities are paired discussions, self-analysis questionnaires, personality questionnaires, time out, observing activities, feedback from others, coaching, and interviews. Since Theorists like to understand the theory behind the actions, mobile student centred LA are not very valuable for them.

5 Conclusion

Research results have shown that mobile student centred learning activities using tablets based on problem solving, personalisation, collaboration, content creation, and flipped classroom are more flexible than traditional teacher centred ones, they have more possibilities for feedback, more actively engage students in learning, facilitate interaction and collaboration, employ multiple teaching methods, and incorporate learners' backgrounds, experiences and expectations.

Research results show that the proposed quality evaluation approach refined by Fuzzy method to establishing both quality criteria weights and values:

(1) is applicable in real life situations when educational institutions have to decide on using particular learning activities for their education needs, and

(2) could significantly improve the quality of expert evaluation of learning activities by noticeably reduce of the expert evaluation subjectivity level since they are quite simple and are based on sound scientific approaches.

The experimental evaluation results show that proposed quality evaluation method of learning activities is quite objective, exact and simple to use for selecting qualitative learning activities alternatives for particular learning styles.

On the other hand, proposed personalised quality evaluation approach is applicable for the aims of CCL project in order to select learning activities suitable for different learners needs. Therefore, we recommended this approach to be widely used by European policy makers and practitioners both inside and outside CCL project.

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References

1. Advanced Distributed Learning initiative's web site. http://www.adlnet.org/ 2013.
2. Avery, Z., Castillo, M., Guo, H.P., Guo, J.A., Warter-Perez, N., Won, D.S. and Dong, J., Implementing Collaborative Project-Based Learning Using the Tablet PC to Enhance Student Learning in Engineering and Computer Science Courses. In IEEE Frontiers in Education Conference. 2010.
3. Beres, I., Maguar T. and Turcsanyj-Szabo, M., Towards a Personalised, Learning Style Based Collaborative Blended Learning Model with Individual Assessment. Informatics in Education. 11 (1), 2012. 1–28.
4. Carter, S. and Yeo, A.C.M., Mobile Wireless Technology: A Case Study of its effect on Teaching, Learning and Assessment (TLA). In 8^{th} Wuhan International Conference on E-Business. I-III, 2009. 971–980.
5. CCL (Creative Classrooms Lab): EU LLP project website. http://creative.eun.org/. 2013.
6. Chang, C.S. and Chen, T.S., Ubiquitous Learning Grid: self-building knowledge in cross-boundary virtual learning communities. International Journal of Ad Hoc and Ubiquitous Computing. 8 (3), 2011. 189–201.
7. Chen, Y.B., Wu, C.L., Guo X.J. and Wu J.Y., Semantic Learning Service Personalized. International Journal of Computational Intelligence Systems. 5 (1), 2012. 163–172.
8. Dorca, F.A., Lima, L.V., Fernandes, M.A. and Lopes, C.A., A Stochastic Approach for Automatic and Dynamic Modeling of Students' Learning Styles in Adaptive Educational Systems. Informatics in Education. 11 (2), 2012. 191–2012.
9. Enriquez, A., Gunawardena, A., Kowalski, F., Kowalski, S., Millard, D. and Vanides, J., Innovations in engineering education using tablet PCs – Panel discussion with four institutions. In 36^{th} Annual Frontiers in Education Conference. IEEE Frontiers in Education Conference. 1–4, 2006. 519–520.
10. Graf, S., Lin, T.Y., Jeffrey, L. and Kinshuk, An exploratory study of the relationship between learning styles and cognitive traits. Lecture Notes in Computer Science. 4227, 2006. 470–475.
11. Hanis, M.S.A. and Yaacob, N.A., Device Readiness of Tablet Computer for Classroom Use. In Proceedings of Knowledge Management International Conference (KMICE). 2012. 576–582.
12. IMS LD (Learning Design) Information Model. Version 1.0 Final Specification. http://www.imsglobal.org/learningdesign/. 2003.
13. iTEC (Innovative Technologies for an Engaging Classroom): EU 7FP project website. http://itec.eun.org/web/guest/. 2013.
14. Kurilovas, E. and Serikoviene, S., New TFN Based Method for Evaluating Quality and Reusability of Learning Objects. International Journal of Engineering Education. 28 (6), 2012. 1288–1293.
15. Kurilovas, E. and Zilinskiene, I., Evaluation of Quality of Personalised Learning Scenarios: An Improved MCEQLS AHP Method. International Journal of Engineering Education. 28 (6), 2012. 1309–1315.
16. Lazarinis, F., Green, S. and Pearson, E., Multi-criteria adaptation in a personalized multimedia testing tool based on semantic technologies. Interactive Learning Environments. 19 (3), 2011. 267–283.
17. Literature Review. Evidence of impact of 1:1 access to tablet computers in the classroom. CCL project. June 2013.
18. Learning Resource Exchange Metadata Application Profile v.4.7. http://lreforschools.eun.org/c/document_library/get_file?p_l_id=10970&folderId=12073&name=DLFE-1.pdf October, 2011.

19. Lubchak, V., Kupenko, O. and Kuzikov, B., Approach to Dynamic Assembling of Individualized Learning Paths. Informatics in Education. 11 (2), 2012. 213–225.
20. Meiler-Rodriguez, C., Freire-Obregon, D. and Rubio-Royo, E., New world, new minds: Changing the learning process through the new devices. In 5th International Conference of Education, Research and Innovation (ICERI). 2012. 806–815.
21. Moore, E., Utschig, T.T., Haas, K.A., Klein, B., Yoder, P.D., Zhang Y. and Hayes, M.H., Tablet PC Technology for the Enhancement of Synchronous Distributed Education. IEEE Transactions on Learning Technologies. 1 (2), 2008. 105–116.
22. Morris, N.P., Ramsay, L. and Chauhan, V., Can a tablet device alter undergraduate science students' study behavior and use of technology? Advances in Physiology Education. 36 (2), 2012. 97–107.
23. The MoTIF project, Mobile Learning Survey Report. September 2013.
24. Roscbelle, J., Tatar, D., Cbaudhury, S.R., Dimitriadis, Y., Patton, C. and DiGiano, C., Ink, improvisation, and interactive engagement: Learning with tablets. Computer. 40 (9), 2007. 42–52.
25. Romney, C.A., Tablet PC Use in Freshman Mathematics Classes Promotes STEM Retention. In IEEE Frontiers in Education Conference. 2011.
26. Sommerich, C.M., Ward, R., Sikda,r K., Payne, J. and Herman, L., A survey of high school students with ubiquitous access to tablet PCs. Ergonomics. 50 (5), 2007. 706–727.
27. Stickel, M., Effective use of Tablet PCs for Engineering Mathematics Education. In IEEE Frontiers in Education Conference. 2008.
28. Vassileva, J., Toward Social Learning Environments. IEEE Transactions on Learning Technologies. 1 (4), 2008. 199–214.
29. Wang, H.C. and Huang T.H, Personalized e-learning environment for bioinformatics. Interactive Learning Environments. 21 (1), 2013. 18–38.
30. Wiley, D.A., Connecting Learning Objects to Instructional design Theory: a definition, a Metaphor, and a Taxonomy. Utah State University. http://www.reusability.org/read/. 2000.