ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1, April 2012

WEB-BASED LEARNING OBJECTS FOR SENIOR SCHOOL COMPUTER STUDIES

Edward Zimudzi

Department of Mathematics and Science Education,
University of Botswana, Gaborone,
BOTSWANA.
edward.zimudzi@mopipi.ub.bw

ABSTRACT

The use of ICTs to improve the access and affordability of education is perhaps the greatest unrealized promise of e-development, particularly in developing countries. This paper argues for blended learning in senior secondary school computer studies in which teachers and students can use learning objects to complement traditional teaching/learning methods to deliver computer studies content. We develop a sample of learning objects in computer studies that could potentially be stored and accessed by learners and teachers at senior secondary school level in Botswana. A user-centred design-based approach is used for the development of the learning objects. We argue that together with face-to-face learning, learning objects can be useful for both teachers and students in the teaching and learning of computer studies. The emphasis of the work is to incorporate instructional design theories in the design of the learning objects if they are to facilitate learning at the secondary school level.

Keywords: Learning Objects, Object-Oriented Paradigm, Instructional Design Theories, Blended Learning, Pedagogical usability

INTRODUCTION

Information and Communications Technologies (ICTs) have the potential to improve the quality and delivery of educational material to school students in Botswana. Learning objects, which are digital learning resources that can be shared through the Internet can be used to support learning. They are seen as important in providing quality resources for teachers and learners. They can be re-used.

The government of Botswana has invested heavily in the procurement of computer hardware and software to be used in the teaching and learning of ICT technologies in schools. This has been done in order to promote the use of technology in all aspects of life in the country. All the senior schools in the country have a variety of ICT equipment for use by the students and teachers. There are also some classes taking computer studies as a subject. They sit for an exam after two years of study. Most of the material in use today are textbooks, and some practical work which is done mainly using Microsoft Office applications like Access.

Leena and Luna International, Oyama, Japan.

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

The purpose of this study was to design and develop learning objects for computer studies at the secondary school level. It is our hope that the learning objects would supplement the use of the textbook for teaching computer studies content. The users of the learning objects are school students under the guidance of teachers. It is expected that the learning objects to be developed will help in the learning of computer studies by the student at the secondary school level. The learning objects to be developed will follow a taxonomy proposed by Churchill (2006) that classifies the learning objects into the following types: presentation, practice, simulation, conceptual models, information and contextual representation objects.

Conceptual Framework

Learning objects are commonly viewed as the smallest element of stand-alone information required for an individual to achieve an enabling performance objective or outcome. Grounded in the object-oriented paradigm from computer science, learning objects are central to instructional design theories offered by Merrill, Li, and Jones (1990), and Wiley (2000). These theories support breaking down content into constituent parts, then reassembling that content to meet specific learning goals. When teachers first gain access to instructional materials, they often break the materials down into their constituent parts. They then reassemble these parts in ways that support their individual instructional goals. This suggests one reason why learning objects may provide instructional benefits: if instructors received instructional resources as individual components, this initial step of decomposition could be bypassed, potentially increasing the speed and efficiency of instructional development.

What is a Learning Object?

The Learning Technology Standards Committee (LTSC) provided the following defition:

> *Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. (LOM, 2000).*

Different other groups outside the have created different terms that has narrowed the scope of the LTSC definition.

A learning object can be used for facilitating intended learning outcomes, and can be extracted and reused in other learning environments.

Other definitions result by considering the two related fundamental aspects of learning objects, the digital aspect and the educational purpose. The following have been used:

1. Any digital or non-digital entity for technology-supported learning (IEEE, 2001).

2. Any digital resource that can be reused to support learning (Wiley, 2000).

3. Any digital resource used to mediate learning (Wiley & Edwards, 2001).

4. A reusable digital resource built in a lesson (McGreal, 2004).

6. A content object with a pedagogical component (Clifford, 2002).

We adopt the definition by Wiley (2000) that learning objects must be digital learning resources, i.e.

A learning object is "*any digital resource that can be reused to support learning.*" (Wiley 2000).

The definition rejects non-digital reusable resources, and is used for learning. Learning objects may include digital images, video or audio snippets, text, animations and simulations, and applications, like a Java applet.

Pedagogical Usability

Pedagogical usability has crucial importance when designing learning objects for the secondary school curriculum, and therefore will be taken into account during the design and development of the learning objects. The context of employing learning objects differs between the sector and age of the intended user of the learning object. Haughey & Muirhead (2005) made the point that the use of learning objects varies depending on the age of the learner. In adult settings, learners can use the learning objects independently. In schools, learning objects have been designed for face-to-face classroom instruction. Wiley and Edwards (2001) stated that the potential of reusable learning objects as an instructional technology is good, but will never be realized without a balanced effort in technology and instructional design areas. The lack of balanced effort between technical and learning specifications in online instructional resources and learning objects has not been widely considered for enhancing the online instructional design process or creating effective online reusable learning objects. There is a general agreement that the use of learning objects impacts positively on the overall performance of the students and teachers in secondary schools (Haughey & Muirhead, 2005; Kay & Knaack, 2005; Churchill, 2006; Farrell, Glen & Shafika I. 2007, Hadjerrouit, 2010).

From a technological point of view, learning objects use information technology resources as the delivery mode. These learning objects are embedded within a learning strategy, and are associated with pedagogical values that affect teaching and learning processes in school education. Web-based learning objects would support different topics from the computer studies syllabus. The added value of web-based learning resources (WBLRs) in terms of learning compared to teacher-and textbook-directed instruction lies in supporting the student to acquire knowledge through interactive, flexible, differentiated, and motivating activities (Hadjerrouit, 2010). And this can be provided by current technological advancements. The core of these learning objects is the integration of content, technology, and pedagogy into a system that supports learning. With other words, web-based learning resources exist at the intersection of content, pedagogy and technology (Hadjerrouit, 2010).

Pedagogical usability has been addressed by Nokelainen (2006), who defined a set of ten pedagogical usability criteria that can be applied to digital learning material (see Table 1). The

Leena and Luna International, Oyama, Japan.

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

following table explains in brief the criterion of pedagogical usability as addressed by Nokelainen (2006).

Pedagogical Usability Criteria	
Criterion	**Characteristics of learning objectc**
Understandability	Learning objects should provide a well structured description of the subject information using an understandable language
Learner-control	Describes the student's ability to control the order in which they would like to perform activities.
Goal-orientation	Relates to the learning activity of learning objects in terms of learning goals set by the teacher.
Time	Must allow the student to learn the subject matter within a short, but acceptable, period of time.
Interactivity	Supported through easy and user friendly accessibility of the subject information and task-based activities.
Multiple representation of information	Should provide multiple representation of information using various multimedia elements, e.g. text, graphics, images, and sounds.
Motivation	The material should contain intrinsically motivating tasks and examples
Differentiation	Fitting the subject information to the characteristics of the students, taking into account their abilities.
Flexibility	Provide different levels of difficulty and contain diverse assignments and tasks that are tailored to the students.
Autonomy	Students are able to work on their own, without being completely depended on the teacher.
Collaboration	Students can work together to reach a common goal, giving them a sense of how problem solving can be carried out in collaboration.
Variation	Students are able to use other learning resources in combination with the learning objects.

Table 1: Adapted from Hadjerrouit (2010)

Technical and pedagogic usability are related to each other, and cannot be considered separate when designing learning objects (Hadjerrouit 2010).

User-Centred Design

User-centred design is an approach to software design that grounds the process in information about users through analysis, design, implementation, and evaluation of the software product (Hadjerrouit, 2010). It is centred on technical usability. Developers of the software product translate technical and usability requirements into a system that supports effective learning. Technical usability does not emphasize pedagogical usability, which is of crucial importance in school education. Developers of learning objects need to incorporate pedagogical considerations in the development process. This points to the importance of pedagogical usability in the design

of the learning objects because the learning objects will be used by school children under classroom conditions.

Learning Objects in Secondary Schools

According to Haughey & Muirhead (2005), the overall development of learning objects is still much of a rugged front. Much of this development has been in post-secondary sector, mainly in universities and much of the research focuses on issues in an adult setting. The design and development of learning objects for the secondary schools differs from that in post-secondary settings. Designers have to take into account the culture and climate of classroom.

The USA has got various databases of learning materials that comprise websites, lesson notes and learning objects. They range from sites like MERLOT (The Multimedia Educational Resource for Learning and Online Teaching) that are composed of various affiliations of Canadian and US tertiary institutions, SCORM (Shareable Courseware Object Reference Model) that strives to ensure access to high-quality education and training materials that can be tailored to meet individual learner needs and make available whenever they are required through the development of a common technical framework for computer and new-based learning that will foster the creation of reusable learning content as instructional objects, SMETE (Science, Mathematics, Engineering and Technology Educational content and services to the Apple Learning Services (Haughey & Muirhead, 2005). Some of these initiatives have standards bodies that basically develop technical standards, recommend practices, and guides for software components, tools, technologies and design methods that facilitate the development, deployment and interoperation of computer implementations of education and training components and systems. Examples include IEEE Learning Technology Standards Committee (LTSC), ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe) and IMS Global Learning Consortium which according to its website is "developing and promoting open specifications for facilitating online distributed learning activities such as locating and using educational content, tracking learner progress, reporting performance, and exchanging student records between administrative system".

The development of learning objects in African schools is still in its infancy, though with various challenges. One current schools initiative is the Commonwealth of Learning(CoL)'s Learning Objects Repository (LOR), which provides open content course materials for teachers in all Commonwealth countries, using a free and open source software platform developed in Canada. The African Virtual University (AVU), based in Nairobi, is working with CoL to get learning objects relevant to African teachers into the repository.

There is also a NEPAD E-Schools project that aims to support internet connectivity for all the continent's high schools within 5 years, and primary schools in 10 years via wired and wireless systems. SchoolNet Africa, which has a presence in 30 African countries, is providing shared continental online networking spaces for teachers and learners through their African Education Knowledge Warehouse (AEKW) and African Teachers Network (ATN). It is also trying to build the necessary technical management and troubleshooting skills at school level. There is a challenge on whether these programmes have potential to gradually answer the digital part of the digital commons challenge due to lack of funding from the governments.

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

Learning Objects in Computer Studies

In computer studies, various learning objects have been developed using multimedia authoring tools. The Merlot website has various information technology learning objects that can be accessed only after user registration and log in. A member can contribute any material, and the materials are peer-reviewed. The learning objects on the Merlot website are good for the students in higher education. We think that the learning objects for the secondary school should be more user-friendly. Some of the learning objects are based on visualization tools, e.g. JELIOT system for animating introductory programs in Java. The learning objects on the internet are primarily intended for self-study. Generally, the learning objects currently in use today are meant for tertiary education, not for the secondary school level.

METHODOLOGY

The field of educational technology deals with the design and development of new or adapting existing technological interventions to solve current educational problems. Our problem is concerned with the development of an intervention. We use a design-based applied research. According to design-based applied research works well for developing educational activities or tools in educational technology. It blends empirical educational research with the theory-driven design of learning environments (Wang & Hannafin, 2004; Randolph, 2008).

The design-based research consists of a cycle of five basic stages: analysis, design, implementation, and testing, and refinement. Analysis will focus on the syllabus of the computer studies subject, the curriculum and its objectives. Design will focus on transforming the technical and pedagogical usability into a user-friendly prototype. The prototype is perfected through cycles of implementation, testing, re-design and refinement.

The approach we use is user centred, suggested by Wang & Hannafin (2004), Hadjerrouit (2010), Randolph (2008). The goal of the developmental approach is to help developers to translate technical and pedagogical usability requirements into systems that support learning. The approach uses rapid prototyping in the design phase to produce a number of prototypes that can be revised through user feedback. A number of revisions are necessary to improve the quality of the learning objects through a continuous cycle of gradual refinement.

In this work, a number of prototype learning objects was developed. These will be deployed to get user feedback to improve their quality. Future work involves testing our individual learning objects on a school environment so that they can be improved with students and teacher feedback.

SOFTWARE TOOLS

Various software tools have been used for the development of the learning objects. The major software application used was Adobe Flash Professional, and Actionscript scripting language. Flash Professional can be used to build animations, interactive learning objects, and graphics, and can combine various multimedia elements to build learning objects. We have also used java applets for some animations and simulations.

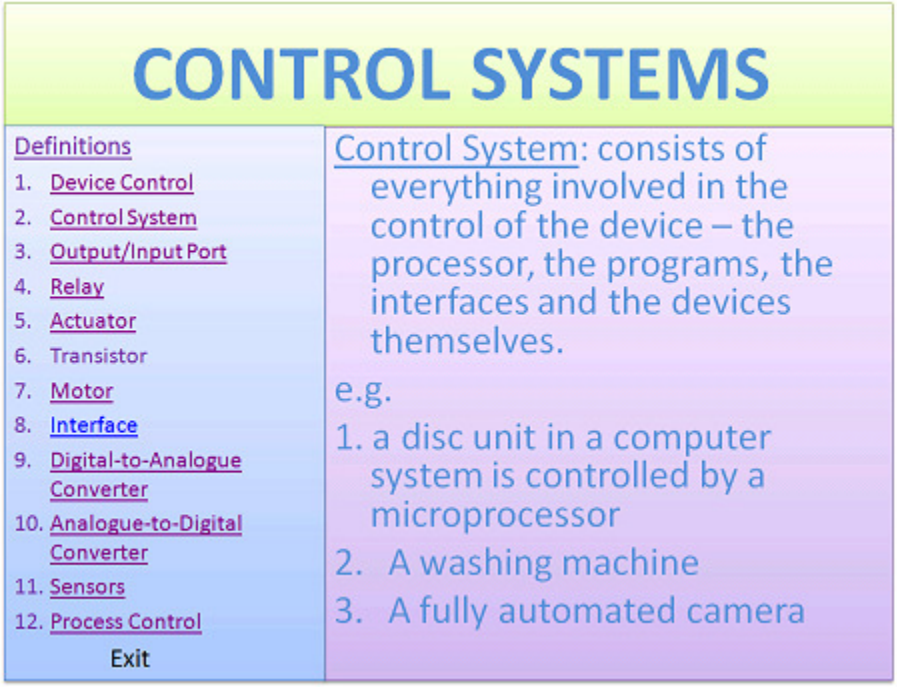
PROPOSED LEARNING OBJECTS

The learning objects that we design are categorized according to the classification by Churchill (2006). The classification of learning objects he proposed could be useful as a framework for designers of digital resources and for those engaged in use of these resources in educational contexts. Churchill (2006) classified learning objects into six unique types which are presentation, practice, simulation, conceptual models, information and contextual representation objects.

1. Presentation Objects

Include resources designed with a purpose to transmit a body of subject matter or lead to achievement of a specific learning objective. A presentation object attempts to transmit knowledge to learners by displaying messages representing chunks of subject matter (Churchill, 2006). This could involve pages of hyperlinked documents with information leading to achieve a certain objective from the syllabus. Presentation material and/or word processed could be usefully used for these kinds of objects.

Fig. 1: Example of Presentation Object



2. Practice Objects

Practice objects allows learners, to practice certain procedures e.g., dry run an algorithm, modelling constructing a certain computer hardware or software, complete crosswords, drag objects, engage with an educational game or answer quiz questions. These incorporate interactivity between the interface and the students during learning of a concept. These encourage problem-solving through active learning.

Leena and Luna International, Oyama, Japan.

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

3. Simulation Objects

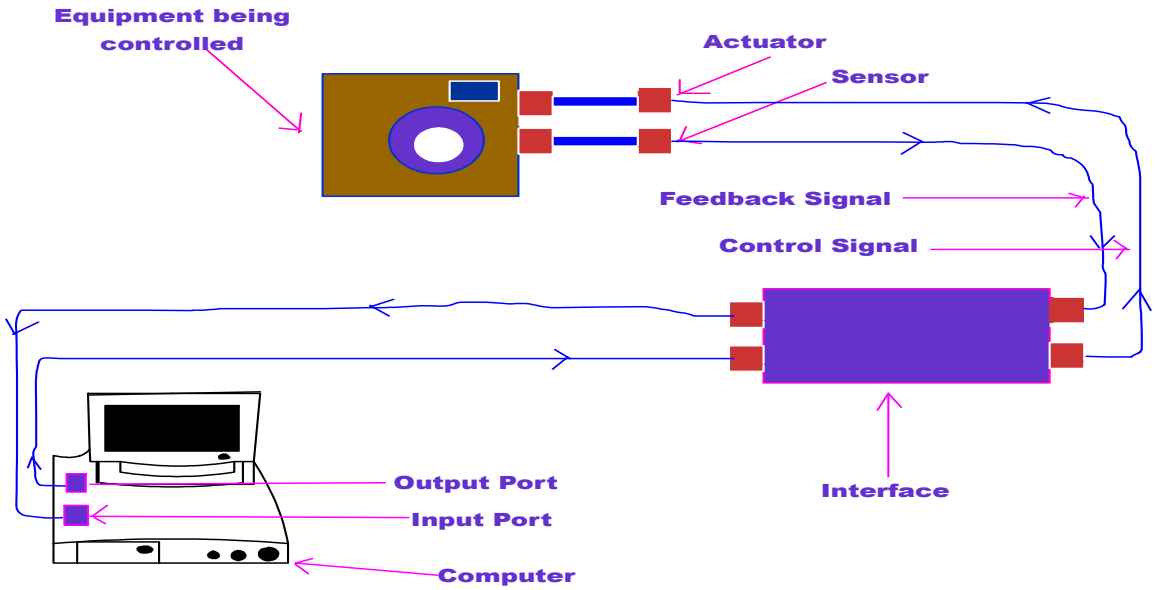
Simulation objects represent some real system or process. They allow the learner to explore operational aspects of a system, thereby developing a mind model of the system's functionalities. In secondary school computer studies, topics in control systems to simulate a real system in place can be easily simulated for effective learning to take place. Simulations to show computer science processes can only be explicitly represented by video, or anything that can represent change over time, like the DAC process in Fig. 2 can be simulated, showing all the conversions by modern-day authoring software like Adobe Flash and Game Maker.

Fig. 2: Diagrammatic Representation of DAC (Digital-to-Analogue Converter)

4. Conceptual model objects

A conceptual model is a type of a learning object that represents one or more related concepts or ideas, usually in an interactive and visual way. It might be appropriate to think of a conceptual model as a representation of a cognitive resource existing in the mind of a subject matter expert, as useful conceptual knowledge that aids decision-making, disciplinary problem-solving and discipline-specific thinking (Churchill 2006).

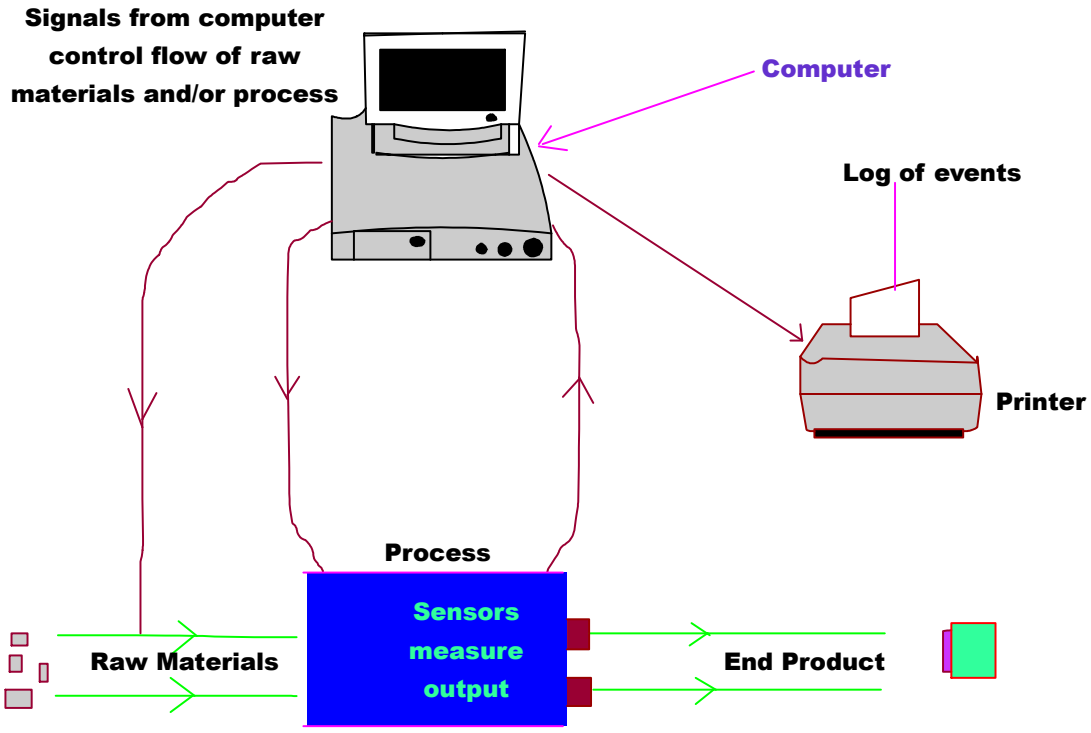
Fig. 3: Diagram of a Control System



5. Information objects

An information object utilizes information visualization capabilities of contemporary technology to provide educationally useful information. This type of learning object might be just a single representation (an image) or a multimodal display and a visual interface providing information dynamically based on interaction. An animation to reinforce a skill or even to introduce a concept is an example of information object.

Fig. 4: Information Object - Process Control System



Conclusions and Future Work

This paper proposes the design and development of learning objects for the secondary school to be used by the teachers and students. Technical and pedagogical usability criteria are considered during the development of the learning objects. Some learning objects were developed that can be deposited in a user friendly repository where the users could access them online.

This work will allow us to examine learning in naturalistic contexts. Context-based computer studies education projects similar to this have rarely been carried out in developing countries, thus there is need to carry out this type of multidisciplinary approach. Also, local innovation and creativity are critical to the welfare of the local communities than is the mere availability of technology from other places.

This paper only deals with the design and development of the learning objects and does not include the empirical part of the research because the research is still in progress. We propose a

Leena and Luna International, Oyama, Japan.

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

follow-up paper to address empirical issues. Rapid prototyping has been used in the design phase to produce a number of learning objects that can be used to get user feedback.

It is our hope that the development of these learning objects will help students and teachers to better manage their computer studies learning activities.

REFERENCES

BGCSE Computer Studies Syllabus. Curriculum Development Division, Min of Education and Skills Development, Botswana.

Churchill, D. (2007). Towards a Useful Classification of Learning Objects. *Education technology research development.* 55:479-497

European schoolnet (2006). The ICT Impact Report. A review of studies of ICT impact on schools in Europe.

Farrell, Glen & Shafika I. (2007). Survey of ICT and Education in Africa: A Summary Report, Based on 53 Country Surveys. Washington, DC: infodev / World Bank. Retrieved January 21, 2009, from: http://www.infodev.org/en/Publication.353.html

Hadjerrouit, S. (2010). Developing wed-based learning resources in school education: A user-centered approach. *Interdisciplinary Journal of E-Learning and Learning Objects.* 6, Retrieved October 7, 2011 from http://www.ijello.org/volume6/IJELLOv6p115_135Hadjerrouit688.pdf .

Haughey, M. & Muirhead, B (2005). The Pedagogical and Multimedia Designs of Learning Objects for Schools. Retrieved 5 June 2011. Available http://www.ascilite.org.au/ajet/ajet21/haughey.html

Kay, R. & Knaack, L. (2008). Investigating the use of learning objects for secondary school mathematics. *Interdisciplinary Journal of E-Learning and Learning Objects, 6,217-238.* Retrieved October 5, 2011 from http://ijello.org/Volume4/ijellov4p269_289Kay.pdf

McGreal, R. (2004). Learning Objects: A Practical Definition. *International journal of Instructional technology & distance learning,* 1(9), Retrieved October 3, 2011 from: http://www.itdl.org/journal/sep_04/article/article02.htm

Merrill, M D (1999) Instructional Transaction Theory (ITT): Instructional design based on knowledge objects, in *Instructional-design theories and models: a new paradigm of instructional theory*, ed C M Reigeluth, pp. 397- 424, Lawrence Erlbaum Associates, Mahwah.

Nokelainen, P. (2006). An Empirical assessment of pedagogical usability criteria for digital learning materials with elementary school children. *Educational Technology & Society*, 9(2), 178-197.

Randolph, J. J. (2008). *Multidisciplinary Methods in Educational Technology Research and Development*. Julkaisija. Finland.

Wang, F., & Hannafin, M. J. (2004). Using design-based research in design and research of technology-enhanced learning environments. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Wiley, D. A. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D. A. Wiley (Ed.), *The instructional use of learning objects* [Online Version]. Retrieved October 5, 2011, from http://reusability.org/read/chapters/wiley.doc

Wiley, D. A. & Edwards (2001). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D.A. Wiley (Ed.). The Instructional Use of Learning Objects. Retrieved October 5, 2011, from: http://reusability.org/read/chapters/wiley.doc