Community Based Software Development – the Case of Movelex

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Abstract. The paper provides an overview of the elaboration, testing and improvement of Movelex, a complex virtual learning environment (VLE) supporting the establishment of self-regulated learning and shared knowledge building space in the classroom. The development and continuous improvement of the software has the aim to form *communities of practice* of teachers and students to co-operate with software programmers in the creation of new functionalities and widening of the array of pedagogical options. Therefore, the VLE called Movelex is not just a product; it is tool and a digital learning content development platform at the same time – and in both capacities, extremely user-friendly and supports building a community of practice for technology-enhanced learning. The paper refers to the *Knowledge Practice Laboratory Project* (KP-Lab), to elaborate new models for in-service teacher training aimed at assisting future teachers in the *co-evolution process* of technical and pedagogical skills development through a VLE enhancement exercise.

Key words: Self-regulated learning, collaborative learning, VLE, communities of practice, Movelex

1. Theoretical Foundations

Virtual Learning Environments have decades of developmental history. Still, they fail to yield educational results promised by their developers – an impressive improvement in the quality of teaching and learning that would justify investment in their development. Teachers, irrespective of the quality and quantity of infrastructure and training courses offered, are still reluctant to use them [1]. According to case studies in 21 OECD countries ranging from school cultures of Mexico to Finland, those who make optimal use of ICT technology are innovative teachers who have been equally successful in “non-digital” educational innovation [2].

Teachers complained that learning management systems (LMS) may have a search functions may convey pedagogical message, but the whole environment represents an “HTML logic” – it does not alter the logic of a book. (Many LMS systems actually contain digital versions of textbooks.) Learning Object Repositories offer independent units that may be interrelated in numerous ways, but teachers find it difficult to match them with curricular content and requirements. Collaborative learning environments (CSILE), for example Knowledge Forum involves co-construction of knowledge – however, text and images are imported into the system from outside sources and re-

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quire considerable investment in time and effort. These tools may also be quite difficult to handle for teachers who soon develop anxiety and avoid the whole ICT culture [3].

Movelex was developed to offer a solution for Hungarian teachers trained in basic ICT literacy but reluctant to use pre-packaged digital material. Movelex invites teachers to act as co-developers: customize and expand an easy-to-use, flexible, still well-structured learning environment. This feature is considered especially beneficial for matching curricula and VLE-s [4].

This VLE focuses on two main pedagogical goals:

- To support *individualised instruction,* self-regulated and cooperative learning;
- To help teacher communities to produce well understandable learning materials supporting the previous goal.

In order to realise these objectives, educational methodology, information technology and the organisation of the use of the system have to be considered in synergy. Movelex differs from most other VLE-s in the following key features:

- Movelex reflects teachers' teaching methods – may be used flexibly for various teaching and learning styles;
- It does not require technological skills – teachers do not have to deal with technological problems and may learn the usage of the system to its;
- Even basic knowledge about this software results in functional learning solutions that teachers can use at once at school;
- The conceptual framework of the curriculum may be directly translated into a set of Movelex learning objects and their relations.

1.1 A Barrier of Self-regulated Learning

A key problem of self-regulated learning is that students have difficulties in identifying their own learning problems and state that it is the "whole" material that they cannot grasp [5], [6]. Lacking easily applicable diagnostic tools, teachers cannot help localising the knowledge deficit or skill development gap because the ruling paradigm in Hungary, frontal education leaves no room for motivation or detection of individual handicaps. Frontal teaching results in a loss of control over individual learning processes by the teacher while learners also loose motivation.

In order to help students identify problematic parts of a learning material and furnish teachers with identification resources, we built our LE on the mastery learning principle. Bloom's model that was based on principles of Morrison and Carroll aims at a profound acquisition of the learning material. Preliminary knowledge is revealed through a pre-test, the remedial learning process is supported by formative assessment and a post-test proves in-depth acquisition of knowledge [7].

Mastery learning became obsolete as an educational paradigm largely due to the amount of work needed for the elaboration of tasks, exercises and testing tools for each learning unit and skill level. Adaptive teaching and testing was in fact extremely time consuming in the era of hierarchically constructed, paper based learning materials. Before the introduction of ICT solutions in education, it was very difficult to separate information from its pedagogical context. When compiling a textbook, the author had to make a final decision about the sequence of the learning units and also the level of difficulty of the material that ultimately pre-selected prospective audiences for the textbook. A printed teaching aid as an object may not be restructured, and additional materials may not be inserted on its pages. Individual differences in interest or learning problems can only be taken into consideration through typography, the separation of core and additional content through colours or printing styles. If another author intends to offer a different methodology, he / she has to write a whole new book, however the information content of this volume will be not much different from the previous one. The two books, however, will be difficult to compare as methodological differences overshadow content similarities.

An example for hidden knowledge: only a few learners will remember what happened in North America in the times of the French Revolution. Both events are there in the history textbook, but on different pages, chapters apart. A history teacher will have learnt so much about different epochs and nations that he / she is likely to be able to forge that link in his / her head. The relations between these two sets of data are hidden knowledge that never becomes apparent for the learner. Teachers, however, find it difficult to understand why these two knowledge elements remain separate in students' minds. Similarly, teachers of physics will be puzzled to find that mathematical knowledge is very hard to activate. Discipline based learning results in compartmentalized knowledge fragments. *The transfer of knowledge* does not occur spontaneously – it has to be constructed through adequate pedagogical means – or a well-designed VLE.

1.2 Learning Objects versus Structured Materials

Learning objects (LO-s), core elements of e-learning material design aim to solve reusability and variability by not containing references to other LO-s. Even these basic units, however, contain a set of concepts that are not explained but may need further clarification. Even if we omit any hints on previous knowledge, it is still there, inherent in the text and / or image of the LO. Therefore, teachers will always have a decisive role in the design of the learning process – even through the selection of the LO-s to be used in the VLE. Both teachers and learners will be in need of help while constructing their individualised knowledge content from what is seemingly a set of reusable learning objects.

Research on *conceptual maps* or Bruner's theory on the importance of "*structure*" both emphasize "interrelationships" as a key design aspect that provides usable knowledge [8]. Even knowledge transfer depends on the ability of the learner to acquire structures and identify special occurrences of a general phenomenon [9]. Our conclusion is therefore that a real educational software solution cannot neglect handling references and structures. Thus, the challenge for educational software specialists is to provide a *dynamic learning platform* with a wide range of learning paths and content options that, at the same time, provides well-designed learning steps and adequate scaffolding for the learner and constant supervision for the teacher.

It is generally accepted that ICT may play a beneficial role in the realisation of contemporary educational paradigms. However, computer technology can do more than that. It can offer a *model for learning as intelligent information processing* that is not attached exclusively to the computer-supported environment. The traditional role of the textbook developer – gathering, structuring and interpreting information – and the major task of the teacher – facilitation of information retrieval, processing and utilisation for learners are concepts well-known in the world of information technology. All these activities centre around the *arrangement* of information – with emphasis on selection, organisation and structuring. E-learning materials, however, often fail to perform this important task. They provide no more than e-books, digitized versions of traditional, linear, paper based textbooks. Even though these transformed texts contain links and images, they have little to do with conscientious arrangement of information and often result in information overload.

The real solution should integrate texts and visualization with database-like internal structures and thus reduce cognitive load [10]. This is the major technological novelty of Movelex, detailed description of this however doesn't fit into this paper.

2. A Trialogical Model for the Development of Learning Materials

Traditionally, teachers "commission" (express a need for) a digital tool or teaching aid and at best, adapt the finished product – if it is customisable at all [4]. Software developers receive a – transcribed by educational policy makers of marketing specialists – description of the functionalities the product is required to have. Learners are also not entitled to take part in the developmental process – all they can do is to select features and content that seems to suit their learning styles, previous knowledge and interest best. The problem is lack of a common frame of reference. Teachers and learners cannot reflect on a VLE in a meaningful way if they have not seen such before. However, if a prototype is prepared for piloting, a large amount of work has to be invested before the product is testable – and understandable – for future users. Making changes is slow and requires vast financial and human investment [11].

The traditional method of educational software development is based on *parallel monologues* – those of the teacher and learner, expressing their need for a digital learning tool, and those of the software developer and producer, expressing their special viewpoints and interests. Learning materials developed as a result can only be used for traditional, authoritative "*learning dialogues*" [12].

The EU-funded Knowledge Practice Laboratory defines an innovative model for the co-construction of knowledge that educational software development also has to consider: *trialogical learning.* "Those forms of learning where learners are collaboratively developing, transforming, or creating shared objects of activity (such as conceptual artefacts, practices, products) in a systematic fashion. Trialogical learning concentrates on the interaction through these common objects (or artefacts) of activity, not just between people ("dialogical approach"), or within one's mind ("monological" approach)." (from www.kp-lab.org, the official Website of KP-Lab: KP-Lab Wiki / Trialogical Glossary) Consequently, the realisation of this learning model needs *communities of practice*. On the one hand, it involves learning in self-regulated student groups ("knowledge building communities"), on the other hand, teachers' communities that co-develop learning content to support and guide self-regulated student learning also have to be formed [13].

2.1 Movelex: a New Type of VLE

In order to realise the trialogical learning model, a new type of VLE is needed that enables teachers and learners to interact with learning content directly, through an easy-to-use and flexible environment and thus act as developers themselves. In an ongoing effort, the teacher and learner community develops *both a VLE and new content to be used within this VLE*. Movelex is more than handy software – it is the catalyst of a new teaching methodology thanks to its structure to be explained below. It is based on the active partnership of the teacher (and, at times, the learner) as a provider of content, and the developer as a provider of technical framework for the formulation of content types (texts, images, assessments, animations, sound bites etc.)

This co-evolutionary process has involved hundreds of teachers who take part in the testing educational functionalities of the software environment and learning materials produced within this environment as well. Trialogical development means here to harmonise the didactic needs, background knowledge and school culture of *educators* (teaching professionals), *software engineers* (ICT development professionals) and *learners* with a deep understanding of their own motivation and interest. These groups do not normally work together on a learning material design task as their roles never overlap.

The Movelex Virtual Learning Environment was constructed on the principles described in this paper and have already six years of practical experience. (Its name generates from the English words "moving" and "lexicon".) Below we will describe the basic components of the system:

- *Digital lexicon:* a knowledge repository that makes the implicit structure of the learning content, in the mind of the teacher, explicit. Several innovative features enrich this digital lexicon:
  - Items are not represented as text, but are marked as definitions, remarks, examples and symbols. Teachers may attach categories like age group, school type, target population etc. and the system will filter the items according to the preferences of the teacher.
  - It is also possible to write different interpretations representing levels of difficulty or professional viewpoints for the same concept.
  - *We can differentiate between new and* (supposedly) *known concepts*. This way we can construct a network of concepts that mutually rely on each other. Thus, necessary preliminary knowledge for a certain unit may be defined and the logical hierarchy of learning items may be clearly identified. Therefore, we can avoid the inclusion of non-defined, new concepts on the network.
  - In the lexicon, links not only denote one lexical item, but always refer to the meaning of a word that is needed for the given learning unit. In the lexicon, *every meaning is listed* – with the respective illustration.
  - Among the concepts in the lexicon, *several types of relationships* may be indicated. Apart from subordination (like furniture – table) you can specify syn-

onyms, antonyms, or such intricate sets of relationships like the table of Chemical Elements, a chain of historic events or the origin of species. The material can be arranged according to different structures, for example, make a list of historic events happening in the same period in different parts of the world. (In a printed book, these would be found in different chapters.)
  - The links themselves may also wear tags that associate them with different relationships, therefore even plain text may reflect different relationships. Links are symmetric, which means that their source may also be searched for.
- *Test bank:* several item types make practising and testing more enjoyable (e.g. matching tasks, selection of the right answer, special linguistic and mathematical tasks, inserted images and other multimedia elements). Tasks and tests may contain references to the lexicon, thus facilitating the learner's work with items to be practiced.
- *Image and graph bank:* there is an inbuilt animation software available to produce animated images that may be used both in the lexicon and the test bank.
- *Virtual Communication Environment:* provides a platform for learners' and teachers' dialogues and for the integration of materials developed by users (teachers and learners alike).

2.2 Using Movelex in the Learning Process

In the Movelex VLE exercises (test or practice items) are produced in a word processor, may be corrected at any time, and will be formatted automatically by the VLE. All the user has to do is to save his / her product as a web page and open it with the Movelex Presenter program which can be downloaded from this web-page: www.perfectstudy.org.

The *basic learning unit* may comprise the elements listed below. (These are options provided by the VLE and do not necessarily have to be used in all by the teacher.)

- *Test of necessary preliminary knowledge:* in case of insufficient solution of these items, it is not advisable to start with the new learning material.
- *The learning material.* It consists of three types of units. The definition of their sequence and elaboration is the task of the author:
  - *Background material*: description of the material to be taught in the form of a *lexicon*. Concepts and facts may be illustrated by images and animations.
  - Pages containing *new content* (series of frames that can be viewed in a definite, didactically designed order).
  - *Tasks and exercises*: explanatory and practice items and illustrations (images, animations) attached to them.
- The unit is concluded by a final test. The results of this test help both the teacher and the learner decide if the learning process was successful or more exercises and / or explanations are needed.

A typical Movelex unit consists of the new content as front page material and the lexicon as well as the tasks and exercises are "linked" to its parts. The lexicon helps interpret the concepts of the new learning content, while the tasks and exercises facilitate its elaboration. Practice items offer immediate feedback. Thus, they may be used as formative tests and facilitate knowledge acquisition through repeated testing opportunities with items provided in a random order.

The above elements may be combined in a different fashion: a new knowledge area or theme might be introduced by simulations and problem solving tasks (to be solved in small groups). After these, the learner may go to the new content pages to overview and structure his / her newly gained knowledge [14].

2.3 Integrating Text and Visualization

The central idea of the VLE is, that *visualisation* leads to easier and more profound understanding. If the teacher intends to use a simple illustration, it is enough to mention the file name of the image in the text description of the learning material. However, if we want to connect the text with the images (for example, we intend to insert an inscription on the picture or caption it), then we have to use the Movelex *animator (drawing)* component. This functionality is also suited to the level of the user.

Captioning an image can be learnt in minutes. The simplest form is to insert words on an image, sometimes through arrows pointing at different parts of the image. An image thus captioned, may also be used as a test item with students having to connect concepts and pictures through arrows. More sophisticated drawings can also be applied on images: for example, the borders of a country may be paired with its name. This requires a little more practice. To create an animation needs more advanced skills, but even this function can be mastered within a few hours. The animation technique is very simple but amazingly effective at the same time. A photograph may be animated as easily as you move a Barbie doll. Children may use their favourite images to make an animation based on a thematic unit, and thus approach a set of scientific problems with more motivation (the downloadable sample task sequence also contains such animations).

Even the advanced level of the animator function may be used by a 12-year-old computer fan, and enables young users to realise a set of interesting visual tricks. The optimal use of this function is through pair or group work, where different skills and knowledge backgrounds may create a synergy.

The aim of the advanced-level *editing programme* is to integrate LO-s and images, animations etc. in a unified learning system. The content integrated in the Movelex VLE is a specially structured knowledge repository that has substantial additional functions. To produce such a repository file you generally need a special editing solution the educational relevance and organisational requirements of which we briefly describe here.

Learning content may be structured in a List of Contents page, similar to the File Manager of Windows. This list may be organised into different rank orders and subgroups (and thus be used differently in different classes.) The program is able to list, based on links in the tasks and among the items of the lexicon, those concepts that are misinterpreted or not known by learners. At the end of the test, the software gives an advice to the learner on previous knowledge he / she has to repeat. Thus, Movelex performs a *developmental evaluation* function and can be used as a formative test. Images may easily be turned into test items, because illustrations are linked to concepts of the lexicon.

2.4 Simplicity as a Key Factor of Feasibility

On the basic level of the Movelex VLE adding new tests or practice items does not require more than word processing skills, only discipline based educational knowledge is necessary. On the advanced level, if a teacher intends to integrate his new test with other learning materials he / she developed or identified in the Movelex learning content repository, more advanced user skills are needed, but even this can be acquired in the course of a two-day training sessions. This training, however, includes more professional (educational) activities than software skills development. Members of a new learning material development group have to analyze the teaching content they intend to transform into digital content in order to create a coherent semantic web of concepts and facts that cover the whole area to be taught and / or tested in the VLE. Software developers are offered the role of technical advisors and invited sometimes to solve special technical problems. Besides they refine the framework according to the needs of pedagogical experts.

3. Results

The first development of learning material (databanks for seven disciplines) for Movelex VLE was launched in 1991. By now, its digital content repository contains about 8000 tasks, based in a lexicon of 7000 items. About 300 teachers have been trained, and 100 of them take an active part in the development of the Movelex repository and tools. *One third of those teachers trained became developers and have been involved in this community of practice ever since.* This community building capacity is considered especially important for improving teachers' educational strategies [15]. As a result of assessment of teachers' ICT skills, two levels of Movelex facilities are offered: Beginner and Advanced, as described before.

In-service teacher training courses organised in small village schools with modest infrastructure and unskilled in computer use teaching staff proved that Movelex is user friendly enough to be employed by students and teachers alike [16].

The *inclusion of learners* in the process of digital content development in this project also served the purposes of talent development. Student skills were put to use in the production of visualisations: the production of graphs, charts, still images and animations and their harmonisation with the accompanying explanatory text. This process involves the processing of verbal information and its transformation into visual signs, symbols and text and image combinations. Talented students will arrive at a deeper understanding of the learning material through this complex process.

Working with Movelex means the harmonisation of interests, experiences and skills of different stakeholders of the learning process. The system of digital content production consists of a set of activities that need to be co-ordinated and monitored. Teachers, university staff members or educational researchers may act as moderators of Internet based developer communities. This process is also included in the co-operative educational project of ELTE MULTIPED and Viola Software Ltd. as a pre- and in-service teacher training experiment and is described in some detail below. In order to provide a *learner centred arrangement of the learning material*, we realise the following objectives:

- Separation of the learning content, learning paths and evaluation.
- Collection and grouping of concepts according to higher order categories and thematic units.
- Based on the *concept repository*, creation of concept maps that facilitate the identification of learning gaps and misunderstandings. The role of the concept map is to make sure the learner does not omit important parts and does not ignore the learning sequence designed by the author of the material.
- To facilitate flexible use – besides ensuring the *coherence of the concept map* – alternative explanations are needed that represent different levels of sophistication and may serve the needs of experts and novices. While accessing explanations and tasks at their own level, they will still experience the concept map as a unified whole.
- Organisation of information in a *database* that enables different ways of connecting, arranging and filtering facts, data and concepts.
- *Integration of visual elements* (images, graphs, charts and animations) with textual descriptions and concept maps.
- *Provision of different learning paths* enable the learner to go through them till the end or choose a new path during learning. The concept map ensures logical sequence and prevents the omission of important parts, as described above. Still, the learner is able to spend more time at any given thematic focal point to ensure deeper understanding.
- *Support for cooperative learning* through the coordination of simultaneous access to information.
- Ensure an easy *follow-up of the learning trajectory* by teacher and learner.

4. Conclusion: VLE as Organiser of Communities of Practice

Self-regulated learning involves the active participation of students, therefore, the environment should also enable learners to generate new content and adapt existing one for individual needs. *Community based content development and assessment* is inevitable to realise the aim of this VLE: to provide a comprehensive and constantly expanding digital learning content repository [17].

Members of this community are not only educationalists, but also civic associations and companies. The technological framework for the functioning of this community of practice (CoP) is a VLE that offers tools for content development and a sophisticated platform for teaching, learning and assessment. The relatively simple content development component assures that Movelex is used by expert and novice ICT using teachers and students alike. This feature is especially important in Hungary where the level of ICT knowledge and skills of educational stakeholders is extremely diversified.

According to the diversity of ICT skill and interest of stakeholders communities have to be organized as Communities of Practice on multiple levels [6]:

- Basic level development is done in small local groups – as described above – using a word processor. The simplest way – suitable even for novices in ICT – is sending the document to each other by e-mail and writing corrections directly into the text.
- Group work for designers on advanced level may be facilitated by a special *networked mode:* here, the software and database is running on the PC of every group member and all of them are linked through the internet. Modifications done by any of them are synchronised and seen by his / her peers.
- The integrated database of LO-s is offered for testing to the final users (teachers and students) who still have a special technique to give feedback to the designers. They can make remarks on any point of a screen layout as if sticking a ticket on it. Designers get back all these remarks integrated, make necessary corrections and issue a new release of the material.
- At advanced level, this response system works as an integrated shared space, as group members can reflect even on each-other's remarks. These are logged by the system in a searchable database documenting this way the evolution of the trialogical developing process.

The next phase of the project is the testing this trialogical software development model in teacher education. As members of the Knowledge Practice Laboratory (KP-Lab) team, ELTE and Viola Software Ltd. will explore the potentials of this software development model both in in-service and in pre-service teacher education. The course incorporates a combination of knowledge practice models:

- Knowledge creation in small and large peer groups;
- Knowledge creation in an online, "ask the expert" context;
- Micro-teaching;
- Synchronous / asynchronous online forums complete with whiteboard functionality for real time co-operation through drawing.

These features represent collaborative knowledge creation [18] and serve as an example of trialogical learning. Elaborating existing knowledge practices will be an important feature of the course. Design expertise of art education students will be used to form a generally shared knowledge base for learning about the role of visualisation in teaching and learning processes. Missing animation options of Movelex will be highlighted by students and their tutors. Staff of the software development firm invited to discuss online, how these, necessary for teaching features could be included in later versions of the software. Thus, a trialogical approach to software development is realised.

The pre-service group will comprise of art education students in Budapest who will focus on the visualisation potentials of Movelex, while in-service teachers cooperating in Hungary and Romania (Cluj) will represent a wide range of school disciplines and professional interests and will experiment with all features of Movelex.

References

1. Liu, Yuliang, Huang, Carol: Concerns of teachers about technology integration in the USA. European Journal of Teacher Education, 28 (1) (2005) 35-47
2. Venezky, Richard and Kárpáti, Andrea eds.: ICT, Education and Innovation . Special Issue, Education, Communication and Information. Vol. 4, No. 1 (2004)
3. Wood, Allen, Mueller, Judy, Willoughby, Teena, Specht, Jacqueline, Deyoung, Ted: Teachers' perceptions: barriers and supports to using technology in the classroom. Education, Communication, Information, 5 (2) (2005)
4. Leahy, Margaret, Twomey, Denis: Using web design with pre-service teachers as a means of creating a collaborative learning environment. Educational Media International, 42(2) (2005) 143-152
5. Mayer, Richard, Moreno, Roxana: Aids to computer-based multimedia learning. Learning and Instruction, 12 (2002) 107-119
6. Paavola, S., Lipponen, L., & Hakkarainen, K.: Models of Innovative Knowledge Communities and Three Metaphors of Learning. Review of Educational Research 74(4) (2004) 557-576.
7. Bloom, Benjamin S.: All Our Children Learning. New York: McGraw-Hill (1980)
8. Kimber, Kay, Wyatt-Smith, Claire: Using and creating knowledge with new technologies: a case for students-as-designers. Learning, Media and Technology, 31 (1) (2006) 19-34
9. Bruner, J: The Process of Education, Cambridge, Mass.: Harvard University Press (1960)
10. Kirschner, Paul A.: Cognitive load theory: implications of cognitive load theory on design of learning. Learning and Instruction, 12 (2002) 1-10
11. Herrington, Jan – Standen, Peter: Moving from an instructivist to a constructivist learning environment. Journal of Educational Multimedia and Hypermedia, 9 (3) (2000) 195-205
12. Liu, Min, Gibby, Scott, Quiros, Ondrea, Demp, Elaine: Challenges of being an instructional designer for new development: A view from practitioners. Journal of Educational Multimedia and Hypermedia, 11 (3) (2002) 195-219
13. Paavola, S. & Hakkarainen, K.: (2005). The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning. Science & Education 14(6), 535-557.
14. Gros, Begona: Knowledge Construction and Technology. Journal of Educational Multimedia and Hypermedia, 11 (4) (2002) 323-343
15. Kerr, Stephen: Why we all want it to work: towards a culturally based model for technology and educational change. British Journal of Educational Technology, 36 (6) (2005) 1005-1016
16. Kárpáti, Andrea: Travellers In Cyberspace: ICT In Hungarian Romani (Gypsy) Schools. In: Kárpáti, Andrea Ed. (2004): Promoting Equity Through ICT in Education. Paris: OECD (2004) 141-156
17. Hakkarainen, K., Palonen, T., Paavola, S. & Lehtinen, E.: Communities of networked expertise: Professional and educational perspectives. Amsterdam: Elsevier (2004)
18. Amory, Alan, McNaught, Carmel: Collaboration, design and technology – themes in the architecture of interactive learning environments. Journal of Interactive Learning Research, 12 (2/3) (2002) 149-153