An Intelligent Mobile Tutoring Tool Enabling Individualisation of Students' Learning Processes

Pasi Silander, Häme Polytechnic University of Applied Sciences and University of Joensuu, Finland (pasi.silander@hamk.fi)

Anni Rytkönen, Department of Computer Science, University of Helsinki, Finland (anni.rytkonen@cs.helsinki.fi)

Keywords: mobile learning, tutoring, learning process, agents

Abstract

Älykkö is an intelligent mobile tutoring tool for teachers. It enables interaction and tutoring dialogue via mobile devices like mobile phones (SMSs) and PDA's. The tool contains semiautomatic and automatic guidance for learners' learning processes, enabling automatic individualisation of a learning process. In addition, Älykkö contains ready-made-tutoring expressions and a documented tutoring dialogue for teachers' use, in order to reduce the teacher's cognitive load, needed just for memorizing. The tool is created based on the examination of the teachers' pedagogical needs.

1. Introduction

Mobile devices like mobile phones bring new dimensions to vocational education. They extend the learning environment and integrate it with real life environments, where learning can occur in an authentic situation and context (Silander et al. 2004). Existing e-learning products and solutions are mainly technology or content driven and they do not pay enough attention to learners' learning processes and to psychological mechanisms of human's learning. In addition, there is no educational technology designed to work especially as a teacher's tool. New pedagogically advanced software, e.g. cognitive learning tools, learning objects and mobile tutoring applications, and hardware, e.g. mobile educational technology, are needed to support the learners' leaning process and to facilitate individual learning based on the needs of contextualised learning.

Our experience shows that pedagogically driven and designed technologies can make difference in the learning settings, if the tools are carefully designed to fit the real users' context and support the individualisation of the students' learning processes. In order to design educational software, the pedagogical foundation is worth of consideration and has to be first defined at some level. The novel step we took in the development process of the Intelligent tutoring tool was to design and create new mPedagogy needed - innovative learning theory and pedagogy suitable for a framework for tutoring students learning in the authentic situation – outside the classrooms or lecture halls.

A pedagogical model for mobile learning should enable adaptation to the various situational contexts of individual's learning, even though on the deepest level, on the level of neuro-cognitive processes, learning can be seen as universal phenomenon. In addition, tutoring of individual's learning process taking place in authentic environments should be based on the design of the learners' individualised learning processes (Koli & Silander 2003).

This paper introduces a mobile intelligent tutoring tool called Älykkö ("egghead"). Älykkö is created based on the examination of the teachers' pedagogical needs for mobile leaning, where 52 teachers were peer-interviewed, and based on the pedagogical model developed for mobile learning presented in Chapter 3.

2. mPedagogy for Mobile Tutoring and Individualised Learning Processes

There are no widely used pedagogical models or principles of mPedagogy that would give attention to the facilitating of learners learning process by tutoring interventions. When design intentional learning process taking place in real environments new kind of pedagogy are needed especially when developing mobile tutoring practices.

2.1. Why mPedagogy is needed in Addition to Methods Used in Web-based Learning

Mobile devices like cellular phones and PDAs bring new dimensions in learning and education. Learning environment extends and integrates to the real environment, when learning can occur in an authentic context. Communication, collaborative knowledge building, observations and finding new innovations describe the student's learning activity in the authentic learning. When using mobile devices, students are able to construct useful knowledge in a real situation.

The past two decades have seen a number of convergences in the field of learning – a convergence that not only applies to the various educational technologies used; but also to the methodologies and the pedagogical principles applied. Educators do not have the same means to influence students in mobile learning as they have in a classroom or even in Web based learning environments. Therefore, it is important to design learning situations from the point of view of the learners rather than from teachers' view.

Learning practices in real environments are influenced by the pedagogical, technical and contextual contexts. Educators have to use different means to foster learning than traditionally have been used. The traditional teaching process does not apply to the mlearning process, because traditional teaching is based on the teacher's teaching process, whereas mobile teaching has to be based on the design of the learner's learning process (Krishnan & Rajamanickam 2005, Koli & Silander 2003, IMS 2003). In mobile learning occurring in authentic environment, situational factors have different influence on the student's learning process than in traditional Web-based distance courses.

2.2. AEFIRIP -Pedagogical Model Developed for the Mobile Tutoring

A theoretically constructed pedagogical model called AEFIRIP was developed to be used as a foundation for our development of the intelligent tutoring tool. AEFIRIP is based on the contemporary learning theories and pedagogical models of eLearning, like Progressive Inquiry (Hakkarainen et a. 2001), Activating Instruction (Lonka & Ahola 1995) and Problem Based Learning (see e.g. Albanese & Mitchell 1993), but it is focused on the characteristics of mobile learning. It is meant to be used with different kinds of mobile devices when learning is occurring in authentic situations. In this context, learning is seen as mobile-CSCL (Computer Supported Collaborative Learning, see e.g. Koschmann 1996) that relies on socio-cultural learning theories (Bruner 1985, Vygotsky 1978 and 1986). In addition to the knowledge construction, individual's perception and cognitive processes, like heuristic and logical inference, are heavily emphasized in AEFIRIP.

Although mobile devices can be tools used during the whole knowledge building process, we mainly focus on examining critical elements of tutoring the knowledge building process taking place in the authentic environment. The early phases of knowledge building, like setting up own problems and questions, context creation and externalisation of prior knowledge are heavily emphasized in various pedagogical models. In the AEFIRIP model, mobile technology is seen not just as a mediator of the learning activity or collaboration, but also as a trigger and platform that includes guidance and support for learning methods and the learning process.

AEFIRIP is an acronym for the phases of the pedagogical model design for facilitating mobile tutoring of learning taking place in an authentic environment. AEFIRIP stands for Activation, Externalization, Focusing, Interpretations, Reflection and Information Processing. The following steps of AEFIRIP model, described in Table 1, have been created in order to structure the learning process and tutoring activity needed.

Table 1. The AEFIRIP pedagogical model for mobile learning and tutoring consists of following phases.

Phase	Description of activity
1. Activation	**Activating student's prior knowledge and cognitive strategies by context creation or e.g. presenting so called activating questions**
2, Externalization	**Externalization of student's prior knowledge and thinking models. Students become aware of their prior knowledge by making it visible and exposing it to reflection.**
3. Focusing	**Focusing students perception and cognitive processing in a authentic learning environment according the objectives of the learning situation (e.g. by focusing questions or assignments)**
4. Interpretations	**Explicit interpretations done by student based on perception and prior knowledge/cognitive strategies as well as situational factors.**
5. Reflection	**Reflection of own interpretations and situational factors.**
6. Information Processing	**Information Processing consist of sub learning processes (cognitive processes) such as problem solving, classification, comparison, elaboration etc.**

The problems being solved during the mLearning process should be as authentic as possible. The same applies to mobile tutoring and learning assignments that must not be tasks done just for the teacher. Authenticity requires that the culture of professional expertise, i.e., a workplace with authentic tasks, methods, tools, and information sources, should be closely related to tutoring practices. The tutoring and structured learning process makes working in the real environment an intentional and scaffolded learning process needed in order to achieve goals of formal education.

3. The Pedagogical Needs and Possibilities of Mobile Learning on Teachers' Perspective

In the conducted study, 52 vocational teachers were peer-interviewed in order to examine, (1.) what kinds of mobile technology applications are needed to promote learning in authentic situations, (2.) what kinds of learning environments or tools would support open and distance learning, as well as (3.), how to facilitate the teachers' work like tutoring and guiding the students' learning processes by advanced mobile technology. The tool Älykkö is created based on the examination of the teachers' pedagogical needs.

3.1. Procedure of Teachers' Peer-interview

This pilot study involves 52 teachers who had previous experience in Web-based teaching and were familiar with learning with Web-based open learning environments, like Moodle or WebCT. Teachers were attending to the in-service training organized by the Finnish National Board of Education and they were working with the development projects of Web-based education or learning materials. The majority of the teachers (44) worked in the vocational education institutes of various fields while 8 teachers' backgrounds were a high school teacher or they were developer of elearning on communal level. Regional distribution of participants covered quite widely the whole Finland, both urban and rural areas of the country.

The topic and purpose of the research were first introduced to the teachers and then the peer-interview as the method was introduced to them. The peer-interview is a method where one participant interviews another one and then vice versa. Interview was pre-structured and based on the ready-made questions printed on paper. Participating teachers were given as much time as they needed to complete the interviews, although the average time it took was around 40 minutes.

3.2. Results of the Peer-interviews of the Teachers

Our findings are based on the content analysis of the teacher's peer-interviews. The content analysis of the interviews was conducted by using qualitative data analysis software ATLAS.ti. The grounded theory (Glaser & Straus 1967, Straus & Corbin 1994) was used in order to create classes in the analysis process. The answers were classified at the first stage based on the role of the *information and communication technology* (ICT) and students' activity in a learning situation. At the second stage the teachers' answers were examined more closely in order to investigate what kinds of needs and possibilities they would see for using mobile technology in education.

What kinds of learning environments or tools would support open and distance learning? Based on the analysis of the interviews, teachers have a noteworthy need for pedagogical software tools (see Table 2) for constructing learning process. There do exist Web-based open learning environments for distance education, but tools for constructing learning process in the Web are deficient. In addition, learning objects and student's learning tools, like mind tools seem to have a significant role in distance education, according to the teachers.

Table 2. Pedagogical applications of information and communication technology needed in order to facilitate distance learning and Web-based education reported by teachers in peer-interviews (25 peer-interviews).

Pedagogical application of ICT needed for distance education	Freq
Software packages for constructing and designing learning process (teacher's tool)	11
Web-based open learning environment	12
Learning objects and learning materials	13
Learning tools for students (cognitive tools and mind tools)	8
Applications for communication, interaction and tutoring	9
Information retrieval / search engines	2

Communication and interaction in learning situations were seen one of the important roles of educational technology as well as tutoring dialogue between teacher and students. There were reported needs for asynchronous and synchronous tools for communication among the students and between a teacher and students.

Teachers participating the interview did not emphasize the role of information retrieval or search on the Web. This might be because of nowadays' Internet search engines (like Google) wide use in Finnish schools. On the other hand, searching the reliable and scientific information from Internet resources, like article databases, is often considered to be too demanding or purposelessness e.g. for the students of vocational educational institutions.

What kinds of mobile technology and applications are needed to promote learning in authentic situations? The role of the mobile application and technology in authentic learning situations (learning outside the class room, like learning situations during learning-on-the-job periods) was seen more like using existing computer applications or using mobile devices as a notepad or a recorder (see Table 3). Wireless and mobile devices that have a capability for Internet access were found the most useful.

SMS (Short Message Service) was seen as a good tool for tutoring learning in authentic learning environments. SMS messages could be useful when students have problems or questions to make and messages could also be used for giving instructions to students as well as for writing a learning diary or a learning log book that are stored in the Web environment. The strength of the mobile technology in the authentic learning situations is naturally that it's usable anywhere and at any time.

None of the teachers mentioned a need for learning material accessible via mobile devices like communicators or PDAs, although broadcasting the video image to mobile phones was considered to be useful in authentic learning situations. In

the first place, according the analysis of interviews the pedagogical role of mobile technology and applications in the authentic learning environments is interaction; transmitting instruction to student and tutoring dialogue between a teacher and a student. In addition, there was no indication, that mobile technology and application could be used intelligently in the sense of computer science or that there could be automatic functions or learning tools that would facilitate students learning process.

Table 3. Mobile technology needed to promote learning in the authentic learning situations based on the interviews.

Mobile technology	Freq
Hand-held computers like PDAs or communicators	14
Internet access capable hand-held device	12
Short Message Service capable device (e.g. mobile phone)	8
Capability to store data like own pictures and notes	8
Capability to transmit video image on the hand-held device	5

How to facilitate the teachers' work like tutoring and guiding the students' learning processes by advanced mobile technology? The teachers were also asked how mobile technology would help and facilitate the teachers' work like tutoring and guiding students' learning processes. Answers were focused, not on the technology but on the educational practices that it enables. Implicit assumption was that teachers would have hand-held devices with Internet access and send and receive SMS-messages. The educational practices that mobile technology may be used are shown in Table 4.

Table 4. Mobile technology may be used in following educational practices in order to facilitate teachers' work. Educational practices are classified in 7 classes listed in the left column.

1. Tutoring and guidance of the learning process:	**Tutoring by SMSs**
	Blogs
	Student's inquiries
	Receiving and answering student's acute questions in problem situations
	Reaching students rapidly
	Tutoring by video phone calls
	Providing help by SMSs if needed
	Maintaining tutoring dialogue
2. Receiving students products:	**Getting students answers to learning tasks / assignments**
	Getting material like pictures and text gather by a student in an authentic environment
	Easy access to students learning diaries / learning log books
	Easy access to students observation logs and reports
3. Communication:	**Chat**
	One-to-many communication
	Real-time Interaction
4. Evaluation / assessment:	**Student's portfolio**
	Gathering continuous evaluation information on students learning
	Gathering evaluation information from authentic learning situations
5. Working on open learning environment	
6. Positioning of students (GPS)	
7. Simulations	

Pedagogical needs for using mobile technology in a learning process. On the interviews participants were generally unable to explicitly identified or characterize circumstantial pedagogical needs for use of mobile application and mobile technology, though they had described in the other questions how and what kind of educational mobile technology and educational application should be used in order to promote learning and in order to facilitate teachers' work.

4. Älykkö – An Intelligent Tutoring Tool Enabling Individualised Learning Processes

We have developed an application for tutoring students' individual learning processes, based on the examination of the teachers' pedagogical needs and using AEFIRIP model as a pedagogical framework for the development work and piloting procedures of the system. Älykkö works as a basis for mobile learning and for tutoring dialogue between students and teachers. In addition, it enables the creation of the structure and framework for mobile learning process taking place in authentic environments. Älykkö is a PHP- and MySQL-based application with automatic and semi-automatic tutoring features. It forms an Open Learning Environment (OLE) for both PC and mobile devices. The learning environment is open in the sense that students are able to construct the individual content of learning in the form of the portfolios and communicate with tutors by using the tutoring dialogue log.

4.1. Intelligent Tutoring Agents in Älykkö

Älykkö is primarily a teacher's tool and it provides ready made, pedagogical structure for tutoring processes and scaffolds for learners' learning process. Additionally, it solves many problems related to the teacher's tutoring work making it less time-demanding and focused on pedagogical issues instead of memorizing or document management.

Älykkö provides various features for automatic and semi-automatic tutoring of the learner's learning process. These features are implemented via Tutoring agents that are based on the agent technology utilizing also information got by metasearches done via existing search engines on the Web like Google. Tutoring agents have been pedagogically designed based on the needs analysis done as the peer-interview of the teachers. The features of agents are presented in Table 5.

Table 5. Intelligent agents of Älykkö provide semi-automatic and automatic tutoring.

Agent	Function
1 Triggers	Trigger-agent sends automatic trigger messages to students in order to activate students and bring up new angles. In addition, automatic trigger messages are used to initiate interaction and maintaining dialogue when needed. Triggers are context sensitive.
2 Pre-structured Pedagogical Cycles and Scaffolds	Pre-structured pedagogical cycle scaffolds students learning process. Teachers may define in advance the pedagogical model and/or pedagogical cycle used in automatic tutoring. Agent follows students learning process by observing students dialogue messages and sends automatically tutoring messages according the stage of the pedagogical model. This is used in order to structure students' learning processes and promote students' progress. Tutoring messages are sensitive to individual learning processes. Teachers may use ready-made tutoring expression or define their own messages and pre-structured cycles that works scaffolds for student.
3. On-Demand Tutoring Help	Automatic answers are generated to Students' questions concerning the subject domain and e.g. practical issues of studies by utilizing the information on the FAQ-database and documents defined by the teacher as well as information available via internet search engines. Help, hints and links are provided to a learner on demand. On-demand tutoring agent response to the commands "help me on…" and "give me hint …" Agent work iteratively in order to ensure appropriate answers for students and simultaneously update FAQ-database. Students rate the relevance of provided answers.
4. Automatic Iterative Tutoring Dialogue / Conversation as Scaffolds	The agent provides focusing and deepening questions to a student based on the student's progress and activity. These questions helps student to get deeper on his/her subject as well as to reflect and develop further his/her conceptual constructions and artifacts. In addition, so called *dialogical inquiry questions* are sent to students, e.g. "*How did you end up to these results?"*
5. Tutoring On-Demand Questionnaire	If a student needs more personal tutoring, the agent present questions to the student that the student is supposed to answer. The answers are documented into the database. By answering the questions, students have to consider problem from different angles and try to generate solutions to the problem she/he has. The questions help students to see a larger picture and organize pieces of information he/she has. If the student still needs further tutoring, student's answers are transmitted by an email to the teacher who can reply and advice the student. Student's answers provide to the teacher the necessary information needed in order to give effective tutoring.
6. Indicators of tutoring dialogue and relevance of students answers on learning tasks	The agent provides various indicators of tutoring dialogue related to a student's activity, conceptual density and conceptual centrality of content of dialogue. In addition indicators are used to describe relevance to students answer to learning task or assignments. Indicators are presented as visual symbols, numerical values and textual metaphors.

The gents of Älykkö utilize computational measures *conceptual centrality* and *conceptual density* and *conceptual relevance*. These measure are calculated based on the quantitative results got from metasearches via existing search engines on the Web, either focusing on the result based on the whole Web or the documents assigned by a teacher, or both. Teachers can also specify relevant issues to the subject (e.g. in the form of concept map).

The indicators are provided automatically based on a student's answers by the agent described in Table 5. Indicators have chosen so, that they would facilitate students learning process by providing scaffolds like semantic indicators and questions that support learner to develop her/his constructions further. In this setting agents enable enriched individual learning process supported by automatic tutoring.

4.2. Functionalities of Älykkö

Älykkö consists of a portfolio, a documented tutoring dialogue that could be compared to a shared blog between a learner and a tutor and various aids and tools for teachers in order to enable easy, but still pedagogically effective

tutoring and guidance for the individuals' learning processes. Älykkö provides both a Web interface (Figure 1) and a mobile interface via SMS-messaging and Multimedia messaging enabling tutoring and learning taking place in authentic environments, like working places. Communicators and PDAs with GPRS-data and web-connection naturally may be used with Älykkö. Älykkö is also designed to be used as and extension to a Web-based learning environment like Moodle, but it can be used individually or with various other Web-based open learning environments.

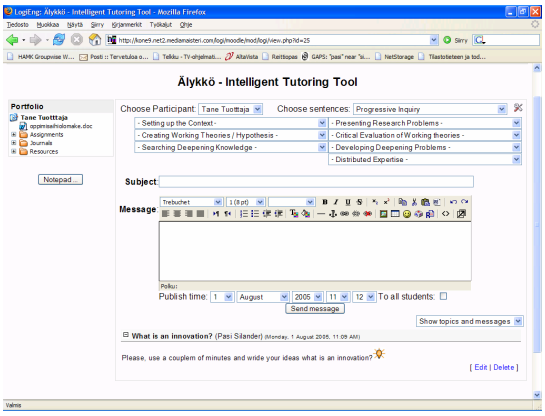

Figure 1. The Web interface for Älykkö.

4.3. Technical Implementation of Älykkö

The Älykkö application consists of the PHP module and the Agents module and the database shared with the PHP Scripts and Agents modules (see Figure 2). Sent SMS messages are transmitted to the IP-based SMS gateway by teleoperators. The SMS gateway processes the SMS messages and directs them, based on the command used in the message, to the selected PHP script and executes the script. The PHP module is used to process user commands and to update the learning dialogue and evoke the agents. In addition, the PHP module handles the sending of notification messages to users' mobile phones via the SMS gateway, as well as sending tutoring messages i.e. the messages sent from the Web interface and messages sent from mobile phones.

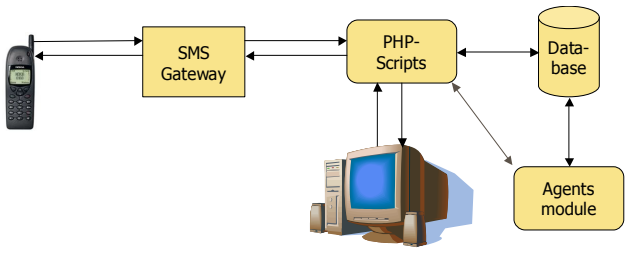

Figure 2. The general technical architecture of Älykkö.

5. Conclusions and Further Perspectives

We conclude that mobile technology and applications may have various pedagogical roles in tutoring activity in a learning setting, but the roles are affected by the context of the learning process, like learning tasks and pedagogical methods, not by the mobile technology itself. The results of committed study show that teachers are, in addition the traditional use of ICT in education, willing to use mobile technology in various domain fields enabling various learners' cognitive processes that facilitate learning. Noteworthy is that the mobile devices alone do not give any functional support to the most of these pedagogical roles or to students' cognitive processes: teachers' intensive effort or intelligent mobile tutoring tools are needed in order to provide this support. None of the interviewed teachers mentioned that mobile learning application could have intelligent or automatic properties, even though they described situations and educational practices where automatic and intelligent tutoring would be the solution. Teachers' structured peer-interviews worked as a notable ground for educational software development, but in order to design intelligent educational technology, the expertise of computer scientists plays the significant role.

We have proposed a pedagogical model for mobile learning called AEFIRIP that relies on the contemporary models of elearning and socio-cultural learning theories. AEFIRIP is focus on the mobile tutoring practices that facilitate individual learning processes taking place in authentic environments. The AEFIRIP model has worked as a framework for developing features of intelligent tutoring tool Älykkö. Älykkö consist of intelligent tutoring agents that provides semi-automatic and automatic tutoring as well as indicators based on student's learning process enabling individualised tutoring process for students, even without teacher's virtual present.

Formative research combining both, developing of hard (new educational technology and software) infrastructures and developing soft (new pedagogical and learning methods) infrastructures is most decidedly needed in order to create and implement successful educational technologies. The emphasis should be on the educational technologies that are easy to implement various contexts and conditions of learning and offers pedagogically meaningful added value. The next step probably is to find precisely, which are the most distinctive features of the tutoring learning process occurring in authentic learning environment with Älykkö and how they could be incorporated in the user model.

Acknowledgements

We would like to thank first of all teachers who enthusiastic develop new elearning practices beside of their classroom teaching duties and also European Social Fund that funds the technical development of Älykkö.

References

Albanese M.A. and Mitchell S (1993). Problem based learning. A review of literature on its outcomes and implementation issues. *In Journal Academic Medicine*, Vol.68, No.1, pp. 52-81.

Bruner J (1985). Vygotsky: a historical and conceptual perspective. In Wertsch J (Ed.) *Culture, communication, and cognition* .Cambridge University Press. Cambridge, USA.

Glaser B & Strauss A (1967). The Discovery of grounded theory. Strategies for qualitative research. Aldine De Gruyter, New York, USA.

Hakkarainen K, Lipponen L & Järvelä S (2001). Epistemology of inquiry and computer-supported collaborative learning. In Koschmann T et al. (eds) *CSCL2: Carrying forward the conversation*, Mahwah, NJ: Erlbaum, pp. 128-156.

IMS (2003) Global Learning Consortium, IMS Learning design best practice and implementation guide, Version 1.0 Final specification 20.1.2003. At http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html 3 April 2005

Koli H & Silander P (2003). Web-based Learning. Designing and Guiding an Effective Learning Process. Saarijärvi: Saarijärven offset / Häme Polytechnic.

Koschmann T (1996). Paradigm shifts and instructional technology. In Koschmann T (ed.), *CSCL: Theory and practice of an emerging paradigm* (pp.1-23). Mahwah, NJ: Lawrence Erlbaum.

Krishnan R & Rajamanickam V (2005). Experience-enabling design: an approach to elearning design. At http://www.elearningpost.com/features/archives/007011.asp 3 April 2005.

Lonka K & Ahola K (1995). Activating Instruction - How to Foster Study and Thinking Skills in Higher Education. *In European Journal of Psychology of Education*, Vol. 10, No.4, I.S.P.A, pp. 351-368.

Silander P, Sutinen E & Tarhio J (2004). Mobile Collaborative Concept Mapping - Combining Classroom Activity with Simultaneous Field Exploration. *In the Proceedings of The 2nd IEEE International Workshop on Wireless and Mobile Technologies In Education, WMTE 2004*. pp. 114-118.

Strauss A & Corbin J (1994). Grounded theory methodology: An Overview. In Denzin, N. and Lincoln, Y. (eds.) *Handbook of Qualitative Research.* Sage Publications, Thousand Oaks, USA. pp. 273–285.

Vygotsky L (1978). Mind in society: The development of higher psychological processes, Cambridge, MA: Harvard University Press.

Vygotsky L (1986). Thought and Language. Cambridge, Mass.: MIT Press.