ViSCoS Mobile: Learning Computer Science on the Road

Teemu H. Laine, Niko Myller and Jarkko Suhonen
Department of Computer Science, University of Joensuu
P.O. Box 111
FI-80101 Joensuu, FINLAND
+358 13 251 7929

firstname.lastname@cs.joensuu.fi

ABSTRACT

We have been running for several years an online study program called *ViSCoS* where one can study the first year Computer Science studies through the Internet. Currently, we are working on transferring the program into mobile devices. The project for expanding the current PC-based solution towards mobile devices has been given a name *ViSCoS Mobile*. We discuss the possibilities and problems related to the design of the ViSCoS Mobile and propose preliminary solutions to them. Three development "threads" for the ViSCoS Mobile are identified: adaptation of the course materials and digital learning tools used in the ViSCoS studies, a possibility to program with a mobile device while learning Java programming and enhancement of student support via mobile learning solutions, such as mobileBlogs. The limited capabilities of the mobile devices are a major obstacle, but we argue that with a proper tool development this issue can be overcome.

Keywords

Mobile learning, mobile devices, distance education, content adaptation.

1. INTRODUCTION

Mobile devices and services have potential to introduce new innovations in the area of education. This is also the case in the Computer Science Education community. The main advantages of these devices, namely limitless mobility and small size, can bring new dimensions to the learning processes of the students. However, despite of the advantages mobile devices are not yet commonly used, for instance, in the distance learning settings. Current course management systems, such as WebCT or Moodle, do not support the connection with mobile technologies [10].

Mobile learning in our case is defined as the ability of using mobile devices to access learning materials and environments. Mobile devices include wide range of technologies from mobile phones with Internet connection to Personal Digital Assistants (PDA) designed to be personal information managers. Therefore, students are able to use several different platforms from diverse locations to study and learn. Learning is not necessarily tied to a specific environment or a learning space.

It has been argued that as long as computers are not ready-at-hand, they will not be used in daily basis on learning and studying [17]. Mobile devices have potential to reach this level. In an ideal situation, learners could use whatever device to conduct learning activities. With a mobile device, students could, for instance, carry their study notes everywhere.

The aim in the ViSCoS Mobile is to allow more flexible ways to study the first year computer science studies. Mobile technologies have also potential to introduce totally new ways to support learning, such as deepening the community awareness among the students. The purpose of this paper is not to evaluate or test already existing solutions, but to elaborate and discuss the possibilities and challenges of the ViSCoS Mobile concept. We also analyze the first potential solutions for implementing the ViSCoS Mobile.

2. VISCOS ONLINE STUDY PROGRAM

In *ViSCoS* (Virtual Studies of Computer Science) online learning program, students study the first year university-level computer science courses via the web. The curriculum of ViSCoS consists of three main areas – the preliminaries of ICT, basics of programming with Java, and an introduction to computer science [7]. ViSCoS courses require about 600 hours of work (equals to 25 credit points in the European Credit Transfer System). The courses are given within three half-year semesters: the aim is to finish the studies in one and a half years time [18]. Table 1 shows the content of the ViSCoS courses.

Table 1. Courses in ViSCoS.

Course	Content
Introduction to ICT and Computing	Introduction to preliminaries of ICT and computing. Practical skills of using word processing and spreadsheet applications, basics of Unix
Programming I	Algorithmical thinking. Basic structures of programming with Java.
Programming II	Introduction to object-oriented programming (objects, classes, inheritance)
Hardware, Computer Architecture and Operating Systems	An overview of architecture of computers, parsers, system software, and databases
Programming Project	Software design. Implementation, testing and documentation of a small application.
Introduction to the Ethics of Computing	General understanding about the ethics of computing
Design of Algorithms	Introduction to basic issues in computer science: algorithms, computation, and data structures
Research Fields of Computer Science	Introduction to a selection of research fields in computer science. Especially those carried out at the University of Joensuu.

ViSCoS studies started in September 2000. At first, ViSCoS was offered solely to high school students in the surrounding area of Joensuu, and it was open and free for anyone who was interested.

Later, the program has expanded to other parts of Finland. From year 2004, ViSCoS is run together with the Continuing Education Center of the University of Joensuu. Adult students can also study in ViSCoS, and the whole program costs 250 euros for high school students and 350 euros for other students.

Table 2 shows the number of students starting and graduating in ViSCoS between years 2000-2005. Altogether 94 students have completed the program during this time. If students pass the program with marks high enough (grade 2 out of 3), they are free to enter the organizing university as computer science majors. In other words: students, who start their university studies already at the high school, can finish their university degree earlier.

Table 2. Number of students in ViSCoS.

Group (starting year)	2000	2001	2002	2003	2004	2005
Student starting	89	184	156	94	101	70
Graduated	22	42	14	16	- *)	- *)

*) studies are underway

3. VISCOS MOBILE

In the *ViSCoS Mobile* project, the aim is to create more flexible ways to study the ViSCoS courses. Although e-learning was promoted by words "anywhere and any time", this is not exactly true. Currently, the students in the ViSCoS program have to use a computer connected to the Internet in order to be able to study. Normally, the computer is located at home with a broadband connection, thus limiting the mobility of the student. Following the idea of ubiquitous computing [21], we would like to be able to offer the students a truly "anywhere and any time" education within the ViSCoS program.

Another issue that motivates us is the developing areas (e.g. in Africa or Asia) where computers and land line connections are rare. In these environments, a mobile device is often the only way to take contact to the rest of the world. Furthermore, there are few possibilities to receive ICT education, even though those skills might have an impact on lives of the people in the form of employment or self-expression [4].

Other issues affecting the implementation of the ViSCoS Mobile are related to the characteristics of mobile devices and network connections. On the positive side, mobile devices have the following promising characteristics [16]:

- small size with high portability;
- instant access without "boot" up;
- flexible solutions can be implemented to support various activities; and
- price – the technology is relatively cheap.

The main challenges of mobile devices are the small screens and difficulties with data input. These factors should not be taken too lightly since they have an important role on user's learning experience. It has been identified, for instance, that users find scrolling through multiple screens of information or entering large amount of text with a mobile device to be troublesome [13]. Unstable data storage and security of personal information are also issues affecting the design of the ViSCoS Mobile [16].

Three possible threads for the ViSCoS Mobile have been identified emerging from the challenges and possibilities of mobile learning. First, the course content and applied digital learning tools in ViSCoS could be *adapted* according to mobile device characteristics. Content adaptation would support the portability of the ViSCoS studies, because students could use variety of devices to access the learning materials and digital learning tools [14]. This would enable more versatile ways to study the courses.

Another challenging aspect is the *programming with mobile devices* during the programming courses (Programming I and II, Programming Project). It could bring new motivational dimensions to the students' learning experiences, if there were possibilities to develop and run programs in mobile devices. Hence, a mobile device would be used as a tool to learn programming. It is already possible to implement a program to a mobile device in the Programming Project course, but programming with a mobile device could introduce new interesting possibilities to the course. The problem with onboard programming is that there are only few programming environments for mobile devices. Tools that are widely used in desktop environments are not applicable in mobile environments due to the technical restrictions of mobile devices, such as small screen size, low processing power and small size of onboard memory. Inconvenient input methods add another challenge to the road towards successful use of mobile devices to learn programming.

Finally, there is a need in the ViSCoS program to enhance the *student support*. For instance, drop out rates in some ViSCoS courses have been a major problem (see Table 2) [18]. If we want more students to finish their studies, new student counseling or supportive efforts are needed. A mobile device could be used, for instance, to enhance social interactivity among the students via data exchange and collaboration [14]. Other natural activities supported by mobile devices are the time management, communication and productivity tools. According to Corlett et al. [3], communication tools and time management activities were the most useful for students learning with mobile devices. Possible student counseling activities implemented in the ViSCoS Mobile are managing the timetables and sending instant messages to peers and instructors. ViSCoS Mobile could also support various learning tools, such as digital learning portfolios and diaries, which can be used to help students to record, organize and reflect on their learning. With a mobile device, the student counseling could become a natural part of students' everyday learning context. Using a mobile device a student can update the digital portfolio instantly when something new happens. For instance, if students discover fresh ideas, they can instantly add them to the portfolio. Students can compose and read carry-on notes. Students could also look up the previous notes whenever they are studying. Learning portfolios could also include activities to share data and experiences among students [14].

4. ANALYSIS OF POSSIBLE SOLUTIONS TO IMPLEMENT THE VISCOS MOBILE

4.1 Content Adaptation

The content adaptation is one of the main challenges in the ViSCoS Mobile. Browsers in mobile devices can actually display many components on web pages, such as images, tables, and forms. Existing research suggests that if users simply read or browse a piece of text their performance may not decrease with a smaller screen size [9]. Simple navigation procedures, such as scrolling, are also not problematic, if the users are familiar with the functionality. However, complex PC-based interfaces can be difficult to access with a mobile device. The content adaptation is used to alter the content according to the constraints of the devices and other factors, such as input and output capabilities, screen size, connection bandwidth, network reliability, and user preferences.

Three techniques applicable for content adaptation in the ViSCoS Mobile are identified: re-authoring, transcoding and structure-aware methods [10]. In *re-authoring*, multiple versions of the content are created according to the device profiles [19]. A feasible solution is to use XML-based solutions, where XSLT style sheet pages are created for different device profiles. Re-authoring is non-generic, because each page and each device needs separate versions of the content. Hence, for large systems and several end-devices, re-authoring is not a viable solution.

In the *transcoding* technique, the adaptation function directly manipulates the HTTP stream [10]. The transcoding engine interprets mobile device's request, fetches the requested content, adapts it, and sends the adapted version to the device [19]. XML-based solutions are also feasible to be used in transcoding based adaptation. Translation and summarization are common techniques for transcoding. A translation function converts the content between different modalities, like text to audio, or video to image [15]. For instance, if the device does not support audio output, the translation function will change the content into textual format. A summarization function modifies the content inside the modalities. For instance, images can be resized to fit the screen. Transcoding engines can also split the page into multiple sub-pages and new navigation is added to navigate around sub-pages. According to Hwang et al. [8], the quality of transcoding can be poor. Especially complex web pages with large nested table structures are difficult to process. Existing transcoding techniques perform local transforms; they do not consider the web pages' overall structure.

Structure-aware methods consider the structure and function of a web page in the adaptation process. In the functional object model (FOM), the objects and their categories are identified before applying adaptation functions to them [8]. A basic object is an elementary component at the web page; it cannot be further divided into smaller units. A composite object is a set of basic objects performing certain functions together. Every object on a web page is assigned a function category, such as information, navigation, interaction, decoration, special function, and page [1]. The FOM method uses rules to handle the objects in a given situation. Rules are either general aimed at all the objects, or specific, focused on certain objects.

Structure-aware transcoding heuristics extract the relative importance of web components by an intelligent syntactic analysis [8]. The content of a web page is first represented with a modified tree structure. The tree structure represents various page layouts, and expresses the interrelationship among components. After the tree structure has been created, the heuristics module tries to find a sequence of transcoding heuristics that satisfy the requirements of different situations (e.g. device constraints). Table 3 summarizes the advantages and problems related to the presented adaptation techniques. The last column includes the possible application areas in the ViSCoS Mobile.

Table 3. Content adaptation techniques in the ViSCoS Mobile.

Technique	Favorable aspects	Problems	Most applicable in ViSCoS Mobile
Re-authoring	+ easy to implement + content is limited, no need for "on the fly" adaptation + learning materials in ViSCoS have similar structure, and they have already been designed for low bandwidth connections. Easy to implement different versions of the content according to pre-defined rules [11]	- non generic - require different version of the course materials; easy but laborious to implement	+ adaptation of the digital learning materials
Transcoding	+ adaptation of dynamic content + XML-based solution	- not usable with complex structures	+ adaptation of the digital learning tools used in ViSCoS
Context-aware method	+ re-usable to other situations	- most difficult to implement - too heavy for needs in ViSCoS	+ adaptation of arbitrary Internet content

4.2 Learning to Program with Mobile Devices

The second identified challenge for the ViSCoS Mobile is to learn programming by programming with a mobile device. In order to find out current state of onboard programming environments and tools for mobile devices, we performed a wide search over the Internet. Against our presumption, we found several software tools, including operating systems, editors, compilers and runtime environments, which could be used for onboard programming on a mobile device. Most interesting findings are presented in Table 4.

The main problem with the existing solutions is that they are very platform dependent. The most promising option for the ViSCoS Mobile is setting up a Java compiler manually. We performed a prototypical installation and configuration of Java compiler which proved us that it can be done on most of the devices running a Java Virtual Machine. This would require additional work because a simple compiler class is not enough – we need tools to automate compiling and running process, as well as tools for convenient source code editing.

Table 4. Onboard programming software for mobile devices.

Name	Type	Platform	Pros/Cons
jCompile	Java compiler	P800 smartphone / Psion	+ free + Java - only Personal Java supported - no product support - very limited platform support
Manual installation of Java compiler	Java compiler	At least PSION Series 5mx, Ericsson MC218 and Compaq iPAQ 3970. Probably many others too.	+ free + Java + possibly feasible in wide range of platforms - old Java (1.1.8) - no ready implementation - requires additional tools
BeanShell	Java source interpretor	Any platform with Java Virtual Machine	+ free + wide platform support - does not conform to Java syntax - not sure whether it runs well on a mobile device
OnBoard C	C compiler	Palm OS	+ free + includes editor - not Java - platform dependent
Mobile Basic MIDlet	Programmin g environment	Any platform with Java MIDlet support	+ wide platform support - Basic - not free (£19.99)
Python for Series 60	Python interpretor	Any Series 60 smart phone	+ widely used platform + free - requires Series 60 Developer Platform SDK - not Java
PythonCE	Python interpretor	Windows CE	+ free + quite widely used platform (PDAs) - not Java - not well documented - under development

In addition to suitable software, onboard programming requires a convenient input method. Research by Copas and Elder [2] compared three widely used mobile device input methods – external keyboard, internal keyboard and Graffiti2 (i.e. Stylus pen). Their overall result suggests that external keyboard excels at speed and accuracy. Also participant satisfaction was greatest with external keyboard. Other input methods, such as thumbwheels, do not provide required input speed for efficient source code writing. While external keyboard seems to be currently the most convenient input method for mobile devices, innovative input devices, such as AlphaGrip [23], might prove to be useful in the future.

4.3 Student Support Activities

When the Internet started it's conquer over the digital world in the early 90's, first private websites started to appear. Many of these pages were static by content and they were updated arbitrarily. There were, however, some pages which resembled much a traditional private diary – only that it was not a private one, nor did it have a physical form. These web diaries were updated frequently and some even had a commenting feature. Some years after the first web diaries were published, the term weblog was introduced. Later this term shrank to blog. Recent development of mobile communication devices have enabled a new wave of blogs – *mobileBlogs, or moblogs* – which authors are able to update wirelessly by means of a mobile device.

According to several researches (e.g. [20][22]) a blog is an excellent tool for organizing and processing learned knowledge and new ideas. They can in fact be considered as online learning diaries [11]. Not only (technically limited) freedom of self-expression is granted to the author, but also constructive comments and brainstorming of ideas are natural part of a collaborative blog system. Our idea is that the ViSCoS students would use mobileBlogs as a tool to facilitate their learning process. To take this one step further, students could carry a mobile device equipped with a camera. Whenever they meet a situation having some connection to the course content, they could snap a picture and send it to their mobileBlog with a related text body. This effect of being ready and motivated to learn anywhere and anytime is a valuable factor for progressive learning. It also expands learning experiences from in front of the desktop computer into new surroundings.

As we see it, blogging would not be only students' privilege, but it could and should be used by the teachers/instructors as well. In this way, students could read their teachers' thoughts and reflect it to their own learning. Conversely, students could express their ideas and give feedback on the course. This would also enable teachers to develop the course based on the feedback. MobileBlogs provide also a valuable tool for teachers to evaluate learning process of the students.

There are a few tools that can be used to support blogging in a distance education course such as ViSCoS. Woven Stories [6] is a collaborative writing tool, which could be used as a part of blogging system to visualize and construct relationships between blog entries. This tool could be also used for individual and collaborative content authoring for example in the Introduction to the Ethics of Computing and Research Fields of Computer Science courses where students need to write an essay or a collaborative study in a given subject. Nokia Lifeblog is another tool that can be used to author a mobileBlog. It is freely available to some of the Nokia's mobile phones and could be deployed in the course.

We have also planned to implement a support system that would enable space- and time-agnostic queries and reminder services for students using mobile devices during the whole study program. Another supportive tool is an instant messenger service, which allows users to communicate more interactively. We could use existing protocols and software, or we could create our own private protocol to be used only within the ViSCoS Mobile.

5. COMPARISON OF CURRENT MOBILE DEVICES

For the current diversity of mobile devices it is very difficult or even impossible to create a system that would support all kinds of devices seamlessly. Dense jungle of different platforms is a nightmare for software developers. When communicational features and input methods differ between manufactures and even between models, the situation seems quite hopeless.

In order to navigate through the possibilities within the ViSCoS Mobile, we decided to evaluate a few machines meeting the following minimum requirements (in addition to be powerful):

- Internal keyboard and possibility to extend it;
- Camera for blogging;
- At least a GPRS connectivity;
- Possibility to send an e-mail;
- Slot of memory extension; and
- Possibility to develop software.

We ended up choosing three devices, each representing different platforms. Nokia Communicator 9500 was chosen to represent mobile phones, while HP IPaq and PalmOne Treo represented “traditional” PDA devices. The chosen devices and their respective operating systems are described in Table 5.

Table 5. Comparison of devices and their platforms.

Device	Platform
Nokia Communicator 9500	Symbian 7.0S OS, Series 80 platform
HP IPaq 6515	Microsoft Windows Mobile 2003 Second Edition
PalmOne Treo 650	Palm OS 5.4

The keyboards in Treo and IPaq seem to be less usable than keyboard of Nokia Communicator. Treo and IPaq contain a stylus pen, but the word recognition quality especially for Finnish seems to be poor. However, the stylus pens can be used as pointing devices. Each of the devices use different platform and only Nokia’s platform is open and can be programmed with C++ and Java. In the HP IPaq, Windows environment can be developed further only with Microsoft’s tools and programming languages. Palm OS used in the Treo has its own tool development environments mainly in C++, but this situation might be changing if Palm is opening their software in the future. Currently, only Nokia Communicator supports Java standards out-of-the-box, namely MIDP and CDCL.

As a result of the small comparison, Nokia’s smart phone seems to be the most attractive both in terms of usability, extensibility and stability. In addition, Series 80 platform together with the tools provided by Nokia form an attractive environment for software development and use in the ViSCoS Mobile. Additionally, even advanced mobile phones are in our experience still far more popular than PDA devices in Finland. Hence, the first concrete solutions for the ViSCoS Mobile will be most probably implemented to Nokia Smart phones. On the other hand, current PDA devices can also be used as a mobile phone and it might be that these devices become popular in few coming years.

6. CONCLUSION

In this paper, we have presented the concept of ViSCoS Mobile. Three possible “threads” for implementing mobile learning in ViSCoS were identified: content adaptation, using mobile devices to learn Java programming and student support activities with mobile devices. Especially mobileBlogs were identified as a promising technology for enhancing the students support in ViSCoS. We also presented preliminary development plans and solutions for the ViSCoS Mobile. Although mobile devices are not currently mature enough, for instance, for onboard programming, we believe that the ViSCoS Mobile concept would bring added value for students. The implementation of the three identified solutions would bring new dimensions to the students' learning. The ViSCoS Mobile would, for instance, enable more flexible ways to access the learning contents in the ViSCoS courses, as well as increase possibilities for social interaction between participants.

The results of this paper can be used as a basis for the concept design of the ViSCoS Mobile. The next step is to implement and test the first concrete solutions to support mobile learning in ViSCoS. There are already students working with XSLT-XML style sheets to adapt the content of some ViSCoS courses. The first steps towards implementing the mobileBlog application have also been started.

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