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THE MOLES AND MINI MOLES SOFTWARE SYSTEM: BRIDGING THE GAP BETWEEN INDOOR AND OUTDOOR LEARNING

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ABSTRACT

In this paper, we present Moles and Mini Moles, a combination of learning software tools that serve in bridging the gap between inside and outside classroom learning experiences. Secondary school students use these tools for hypothesizing, transferring, and testing lessons learned in the classroom into their physical environment. In particular, students use Moles and Mini Moles to create interactive multimedia questionnaires and explanatory material, document outdoor learning situations, and present their findings on the Web. Using the learning software tools in school projects promotes collaborative work, problem solving skills, and organizational skills. Four practical mobile learning project scenarios are described, which focus on cross-disciplinary subject material.

KEYWORDS

Mobile learning, collaboration, knowledge transfer, content management system, XML transfer

1. INTRODUCTION

Mobile learning applications in schools support students' exploration tasks in the physical environment outside their classroom. They encourage students to reflect, explain, and hypothesize about the physical world [11]. These projects exemplify and augment the students' formal classroom learning experiences. In doing so, they comply with situated learning theory [2], which implies contextualization of learning content [6]. Situated learning is one of the hallmarks of the constructivist view [6].

At the University of Luebeck in Germany, the KiMM (Kids in Media and Motion) initiative [5] follows a constructivist/constructionist view [9], where the students actively and creatively use digital media (e.g., PDAs, digital video cameras, iconographic programming software) to create (multi-)media applications or systems. Most importantly, the students are primarily responsible for developing and handling these systems. This implies, for example, collaboration, organization, social interaction, and problem solving on the part of the students.

The KiMM initiative uses computers and other digital media as cognitive tools in a broad range of contexts. We support three general areas, which include interactive mixed-reality performances and installations, web cooperation and pervasive gaming, and mobile and ubiquitous learning [14]. The present paper addresses constructing innovative mobile learning projects in secondary schools (grades 5-13, ages 10 to 19 years old). We work together with teachers, developing project concepts based on the school's curriculum that require students to work in collaborative and self-sufficient learning environments [8]. Projects encompassing the use of software tools and other digital media actively support and enhance the transfer of knowledge both inside and outside the classroom (i.e., digital augmentation [11]).

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2. DEVELOPING INTERACTIVE MOBILE LEARNING PROJECTS

By using a collaborative work model, the student's improve both their problem solving and organizational skills [8]. Thus, from the earliest stages of the project on, an important aspect of our concept stipulates that the responsibility for the project lies primarily in the students' hands. Experiencing the positive outcome of self-initiated activities eventually leads to a high level of self-efficacy, which in turn increases the individual student's learning motivation [1, 10]. The benefits and advantages of students' early involvement in technologically oriented design processes based on participatory design have been demonstrated in related approaches [4]. In a collaboratively oriented mobile learning model, the students' participation and learning begins in the classroom, extends outside of the classroom during a field trip, and is finally completed with a reflective presentation process in their classroom (e.g., sharing their gained knowledge with classmates).

The standard instruction model for school field trips bears the risk that teachers are the main benefactors of indoor/outdoor learning experiences. This is due to the fact that they research and prepare all information needed for the field trip themselves. The teachers carry out all the initial research, prepare extra explanatory material, plan the routes and then create the questionnaire for the students to use during field trips. The students, on the other hand, experience a gap between formal classroom learning and outdoor learning situations. They are not involved in the aforementioned interlinking activities. Thus, the contextualisation (or transfer) of classroom learning content is much harder for the students. In this regard, Rogers and her colleagues [11] concluded that "this separation of interlinked activities can make it difficult for children to see and understand the connections between what are essentially the same representations and processes being studied, albeit in different contexts" [11, p. 56].

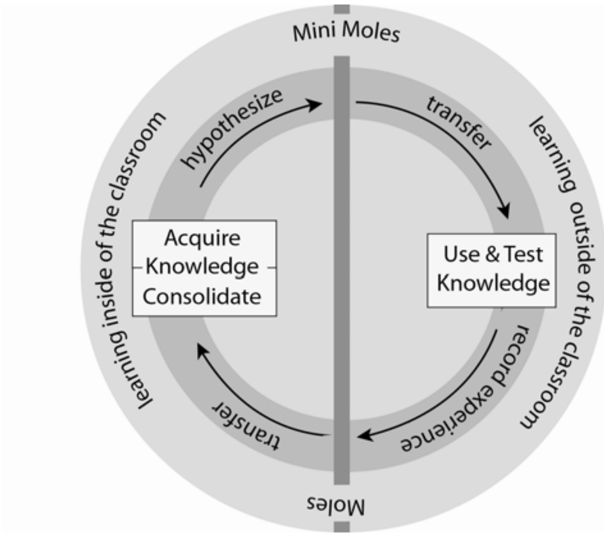

Figure 1. Moles and Mini Moles supporting acquisition and consolidation of knowledge by bridging the gap between indoor and outdoor classroom learning

In our interactive mobile learning model (Figure 1), we address this issue in a closed-circuit loop approach. According to our model, the students' work starts in the classroom. They must consider, with the help of the teacher, what topics in the school's curriculum are applicable for an upcoming field trip (e.g., the life and works of Mozart), which possible scenarios are relevant, and, finally, they have to formulate these ideas into a concept. The students then have to extrapolate how this information can be useful in a real life learning situation. This is reflected in the students creating so-called *testing kits*. Each testing kit comprises a collection of questions to test their acquired knowledge, as well as additional information, which they need during their field trip. This may include a series of tasks, reference and explanatory material, and/or route instructions. Thus, the resulting testing kit goes beyond the scope of standard (paper versions of) knowledge questionnaires.

Outside of the classroom, during their field trips, the students collect data and record their observations in a manner guided and assisted by the knowledge they have previously acquired in the classroom. They also test whether the real life situation validates their hypotheses, which led to construction of the testing kit: Are the questions that they formulated, the tasks that they defined, the explanatory information given, sufficient?

The students then return to the classroom and complete the documentation of their findings for later presentation. With regard to consolidation of learning, students need to reflect upon what they learned by presenting their finding either in the classroom or on the Internet to other persons interested in the project.

The teacher's role is primarily one of advisor and verifier of the project. The teacher and students define together the project content, methodology, and time frame at the beginning of the project. If there are any technical difficulties or if problems arise within the group, the teacher assists the students in directing them towards a viable solution. The teacher also must verify whether all relevant topics are contained in the testing kits and whether the information or data acquired during the field trip is valid.

This closed-circuit loop model illustrates the complexity of the requirements for mobile learning projects. Most importantly, it implies the need for seamless integration of hardware and software system tools. Moreover, software systems evolving from the above-mentioned closed-circuit loop model will support the premise that mobile learning means making the acquisition and transfer of formal learning mobile. Therefore, software tools devoted to mobile learning should feature a high degree of interconnectivity thus providing pervasive environment for learning, a concept Rogers and her colleagues called "Ubi-learning" [11]. This is in sharp contrast to the "anytime anywhere" approach found in some e-learning concepts, which simply promote the idea that the learner be independent from a specific geographical location.

The KiMM initiative set a goal to design and develop software tools, which were conceived to mirror the functionality of Ariadne's Thread in the Greek mythology, thus guiding the students through all phases in the above-mentioned work model. Our mobile learning exploring system tools, *Moles* and *Mini Moles*, are described in the upcoming section.

3. MOLES AND MINI MOLES

The software tools Moles and Mini Moles support projects whose emphasis is on students working in groups, creating future outdoor learning situations (e.g., field trips). First, the students research and create content for digital multimedia testing kits on PCs (Moles), which contains all needed instructional and explanatory information, and knowledge questions. Each testing kit is then transferred onto PDAs (Mini Moles). During their outing, the students record their observations and findings in the PDA and answer questions. They use other digital media (e.g., data measurement sensors, digital photo camera, GPS) as well. Their findings are transferred back into Moles (PC) for Web-based presentation.

Teachers and students (i.e., end users) worked closely together with the KiMM software developer throughout the entire software development lifecycle. This included design, production, and evaluation phases. The motivation behind this was to assure that the end product would not only be usable in a large variety of schools and learning scenarios, but also be compatible with technological systems currently available in these schools. Therefore, innovative and promising hardware-based solutions [e.g., 12], or cost intensive systems [e.g., 13], were out of the question.

With regard to the software, various powerful systems have been proposed that address the issues mentioned above (e.g., the *DataInHand* ™ system [3]). Unfortunately, they do not meet our requirements for the software tools to incorporate a wide selection of multimedia and interactive elements, and still be complex yet easy to use by students of different ages and heterogeneity in terms of computer literacy.

The system specifications for Moles and Mini Moles were as follows:

- comprise information previously learned in the classroom
- support the discovery of the physical world
- allow students to create digital questionnaires on their own
- encourage collaborative work in small groups inside and outside of the classroom
- promote constructive and versatile use of different digital media (e.g. PCs, mobile devices, cameras, and sensors)
- incorporate a wide selection of multimedia and interactive information (e.g. audio, text, photos, sketches, links (HTML))
- take into consideration the severely limited financial resources of the schools and the fact that each school has access to different and often limited types of digital devices

These specifications resulted in Moles, a content management system, which runs on PCs, and Mini Moles, which displays data edited with Moles on PDAs (Figure 2). The Moles system was initially developed as a non-server-based system since the majority of schools have limited or non-existent PC networks and limited Internet access. For this reason, the data is generated on standalone PCs, using XML files and media files, and then transferred onto the mobile devices (i.e., PDA). After the field trip, the data from the completed questionnaire and other collected information is transferred back onto the PCs for final documentation and presentation.

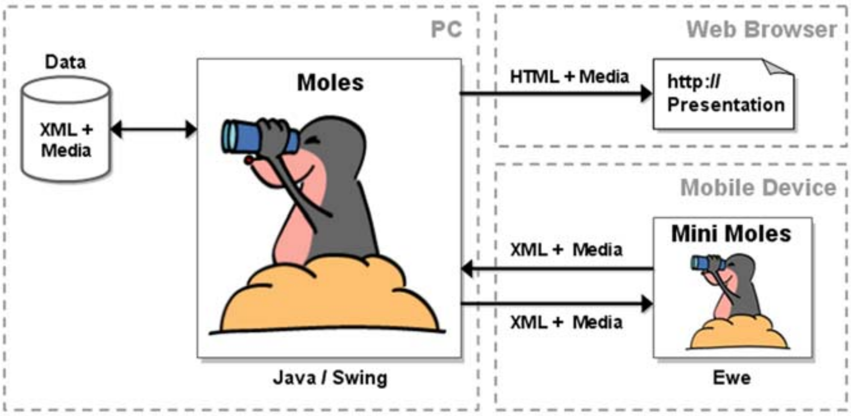

Figure 2. Moles content management system and Mini Moles data transfer for mobile devices

The advantage of using XML is that it structures the data objects, links easily to other media formats, and acts as an interchange format to and from Mini Moles. The DTD (Document Type Definition) defines the structure of the XML document (Figure 3). It is used to control and assure that the information being exchanged back and forth from the PC to the PDA complies with the predefined conventions.

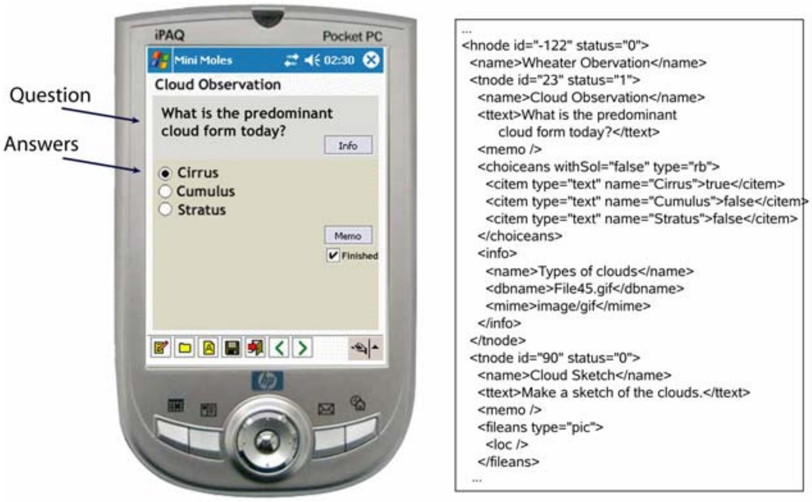

Figure 3. Mini Moles questionnaire on a PDA: a multiple choice question (*left*[1]) and respective XML file extract (*right*)

The Moles and Mini Moles concept addresses three phases of development of common class projects, which will be described in the upcoming section: *research and questionnaire production* (PC), *data entry* (i.e., record observations during the field trip on PDAs and other digital media) *and information access*, and *documentation and presentation phases* (PC).

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[1] Figure 3 displays a translated screen, not an actual screenshot because Mini Moles is currently available in German only. However, there already exists an English version of Moles.

Research

The XML-based Moles was implemented in JAVA. Moles allows secondary school students (grade 5-13) to create interactive multimedia testing kits on a PC using Moles' intuitive graphical user interface (GUI). The testing kits may contain explanatory material and a pool of questions needed for the upcoming outdoor learning situation or field trip. The testing kits are then transferred onto PDAs (Mini Moles).

Data Entry and Information Access

The JAVA-based Mini Moles is a software tool that takes the previously edited testing kits and transfers them onto PDAs. During their field trip or ubiquitous game the students use different sensors and measuring devices, as well as personal observations, to record findings on the PDAs.

In addition, Mini Moles is used as an information source to access explanatory information and route instructions during the field trip. All this needed information (e.g., measurement procedures, background historical facts) is logically linked to the appropriate questions or tasks and accessed directly in the questionnaire on the PDA (Mini Moles; Figure 3 left).

Presentation

When the recorded information is copied back from Mini Moles into Moles and the extra data (e.g., photos) is placed into the finished document, Moles' GUI offers a web presentation function. XSLT files are used as style sheets to automatically export the XML-structured document into a HTML presentation.

4. CREATING MOLES AND MINI MOLES PROJECTS

The above-mentioned three phases of development and the functions and features of Moles and Mini Moles correspond to the respective activities (Figure 4). In the research phase, the students research the topic of interest (assisted by the teachers). They provide photo, audio material, and sketches needed as explanatory information for the testing kits.

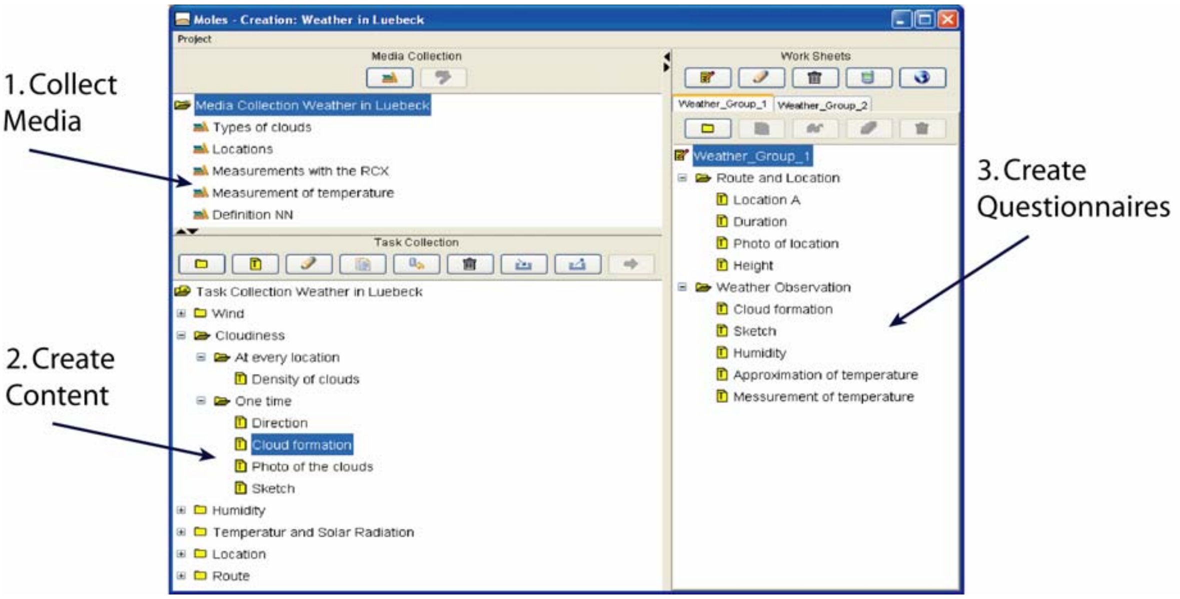

Figure 4. Moles graphical user interface on PC

All of this material is transferred into the media library in Moles (Figure 4: step 1) using the Windows™ file browser.

Next, the students create a non-ordered pool of content (Figure 4: step 2). This includes the following activities:

- creating new folders
- deciding which type of question format is appropriate for each question (e.g., multiple choice, singular or multiple texts, audio, photo and sketch),
- formulating and typing in their questions in a pop-up window (e.g., Q: What is the predominant cloud form today? A: Cirrus, Cumulus, Stratus (Figure 5))
- inserting extra explanatory information (e.g., text, audio, links, photos, or sketches) as needed, and
- selecting and inserting the respective map or routing information

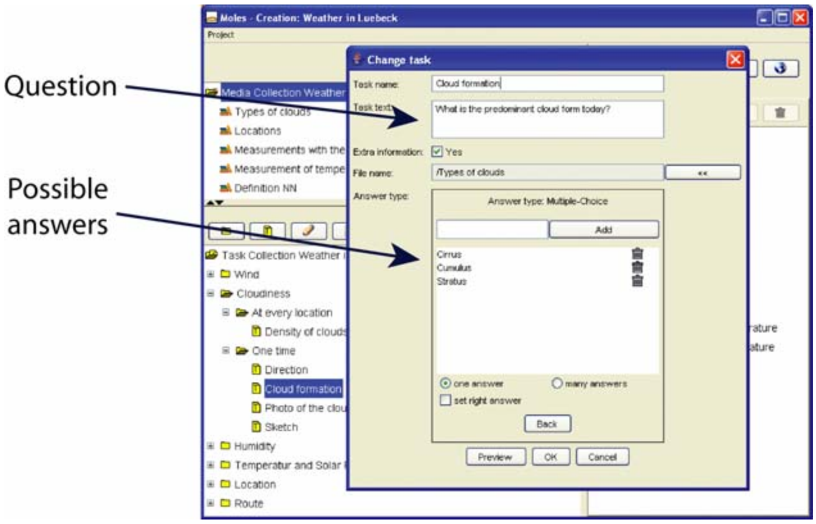

Figure 5. Moles question entry popup window

Finally, questionnaires are constructed by extracting and rearranging items from the pool of content (Figure 4: step 3) for each respective group. The reason for this is that each group on the field trip is likely to take a different route or to answer a different series of questions, as well as the collect and record different data. The teacher verifies the resulting testing kits and which are then transferred to PDAs (Mini Moles).

During the field trip the students record measurement data, observations, and impressions into the Mini Moles GUI on their PDAs. They also use other measurement and recording devices (e.g., air pressure and humidity sensors; see upcoming section). When their field trip is completed, the data files from each PDA, as well as any information or photos taken on other devices, are copied back into Moles (i.e., PC). The answers are checked for correctness by the teacher. The final information in Moles is automatically converted into HTML format for web presentation.

5. USING MOLES AND MINI MOLES IN A PROJECT SCENARIO

The subject material of our mobile learning projects is derived from the individual class curriculum and elaborated in close cooperation with the teacher [7, 8]. In most of our projects, an emphasis is also placed on cross-disciplinary work, thus incorporating a broader scope of subject material into the projects. Here follows descriptions of four project scenarios using Moles and Mini Moles.

- In a museum/school project (German, history, and music classes), the 5th grade class studied the lives of children at the turn of the 18th century. They created aesthetic biographies of five fictitious children (e.g., orphan, pastor’s son, aristocrat’s daughter) in blogs. The biographies were a collection of written stories, drawings, photos, music sequences, and links to related material the students studied and recorded. The students then used this material to create an ubiquitous game with Moles and Mini Moles. The ubiquitous game (on PDAs) was played at a local castle, now museum, exploring what roll art, education, clothes fashion, hygiene, music, and nature played in the lives of children in the 18th century.
- The object of the second Moles and Mini Moles project was to create a math rally for the 5th graders. Senior students (7th and 9th graders from math and art classes) transformed their school from a place of study into a physical mathematical world of numbers, geometric forms, ratios and proportions using the actual

figures and forms found within or outside the school building. In the math rally, 5th graders answered the questions on their PDAs (Mini Moles) that posed fictitious, though practical mathematical problems (e.g., how many 2x3m window panes must the school buy to replace all the windows on the south side of the building).

- In the third project, 7th grade class created a mobile weather project to determine, analyze and record the variation of weather elements in their inner city environment [8]. The students researched and used material acquired from three class subjects (geography: weather elements, mathematics: diagram systems, and physics: measuring systems and sensors) to create interactive multimedia questionnaires (Moles). The 7th graders participated in a field project day measuring and recording weather information at five different "weather stations" distributed throughout the city (Mini Moles).
- The goal of the fourth project was for the mentoring students (10th grade) to create a mobile Advent calendar, an ubiquitous game, for the first year high school students (5th grade). The 10th graders were responsible for planning the project, creating testing kits including interactive multimedia questionnaires (Moles) and organizing the daily event during Advent. The 5th graders, new to the school and unfamiliar with the surrounding neighborhood, went out equipped with PDAs (Mini Moles), GPS, and digital cameras, on a digital treasure hunt inside and outside the school to discover the "door" of their mobile Advent calendar. Each "door" bore a surprise for the 5th graders (e.g. Christmas carols sung in Latin, Spanish, French and English, recited poems by fellow students and teachers of the school). Hence, Moles and Mini Moles assisted the students in gaining spatial (i.e., environmental) knowledge and supported new forms of social interactions.

6. PEDAGOGICAL AND TECHNICAL ISSUES: LESSONS LEARNED

We have presented a detailed analysis of the pedagogical success of the weather project elsewhere [8]. Not surprisingly, comparison of students' pre- and post-project ratings indicated a higher level of general computer expertise after the class project. Accompanying the general acquisition of media literacy, the students also reported stronger positive attitude towards the use of digital technology in schools. On the cognitive level, we observed substantial positive effects in the Advent calendar project. This refers to increases in spatial knowledge and orientation (both in the self-reported data and the teachers' estimations), and social interaction, respectively.

However, the evaluation results also indicated negative or unwanted effects in the practical implementation of the collaborative work model. For example, the students initially found it difficult to come to collective decisions and to delegate tasks. This led to redundancy and, thus, an inefficient work process. Rather than dividing up the tasks, the students tended to accompany each other on the tasks: very often one person was doing the work and the others were purely bystanders. This problem (which is likely to be due to the frontal instructional form most prevalent in German schools) was addressed by requiring the students to keep a written protocol of who was to complete which task when.

We also observed that introducing digital media intensified rather than resolved certain inequalities in group dynamics (i.e., gender related monopolizing of attractive media and material) [8]. This requires that both teachers and KiMM team members continuously and carefully supervise the different groups. In addition, students have to develop a general awareness that certain unwanted effects may occur that need intense communication and collaboration within work groups. Finally, throughout class projects, the students reported that they found it difficult to accept the fact that they would not be given a chance to use all the digital devices. Hence, the disadvantage of not having enough digital devices for all students requires adequate management of resources. This may only be achieved through improvement of communication and problem-solving skills.

With respect to the technical realization, Moles and Mini Moles software tools offer the following advantages over other systems [3, 12, 13]: they are usable in a large variety of school learning scenarios yet may be used on the computer systems currently available, they incorporate a wide selection of multi-media and interactive elements, they are complex but easy to use, they are cost effective, and, unlike other prototypes, have been empirically tested and proven fruitful [8].

In addition, Moles and Mini Moles meet the system requirements (see section 3). However, a specific usability issue and the need for extending the system's communication functions became apparent. With regard to the usability issue, the GUI turned out to be sub-optimal for students younger than 7th grade (age 12 and below). Hence, we are currently developing *Moles-for-Kids*, which will have an intuitive GUI featuring icon-based programming. *Moles-for-Kids* will be used in mobile learning projects from elementary schools grades onwards. Secondly, *Net Moles* addresses the issue that the current version of Moles and Mini Moles require different work groups to come together physically to share their knowledge and collected data. The planned wireless data transfer in Net Moles will establish a sense of social awareness and collaboration between different work groups. Thus, Net Moles will represent a form of communication-oriented computer-supported mobile learning [e.g., 12].

7. CONCLUSION

In addition to the cognitive and work group effects reported in the latter section, the applicability and usability of the Moles and Mini Moles software learning tools were evaluated in each class project. The evaluation data clearly indicated the overall success of our approach in terms of bridging the gap between indoor and outdoor learning [8].

The challenges faced developing mobile and high interactive learning projects are numerous, yet not insurmountable [8]. Positive effects on self-esteem and the promotion of learning performance in school [14] make such projects desirable. The benefits for students are apparent in an increase in their motivation and the efficient and intense acquisition and transfer of knowledge.

Transforming theoretical knowledge acquired in classroom studies into accessible, real, and practical tasks for outdoor learning is a challenge. By supporting contextualisation of the learning content, the Moles and Mini Moles software tools meet this challenge, acting as a guide inside and outside the classroom, not unlike Ariadne's Thread in Greek mythology that warranted safe navigation through a labyrinth.

REFERENCES

[1] Bandura, A.: Self-efficacy. In Ramachaudran, V.S. (Ed.): *Encyclopedia of Human Behavior 4*. Academic Press, New York (1994) 71-81.

[2] Brown, J. et al, 1989. Situated Cognition and the Culture of Learning. *Educational Researcher*, Vol. 18, No. 1, pp. 32-42.

[3] DataInHand™, http://datainhand.wfu.edu/, accessed Feb.15, 2006.

[4] Guha, M. L. et al, 2005. Working with Young Children as Technology Design Partners. *Communications of the ACM*, Vol. 48, No. 1, pp. 39-42.

[5] KiMM, Kids in Media and Motion, http://www.kimm.uni-luebeck.de, accessed Feb.15, 2006.

[6] Lave, J. and Wenger, E., 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge University Press, Cambridge, England.

[7] Melzer, A. et al, 2005. Evaluation of a Mixed-Reality and High Interaction Media Project in the Classroom: Strategies and Methods. *Proceedings of ED-MEDIA 2005*, Norfolk, USA, pp. 3984-3991.

[8] Melzer, A. et al, 2005. Developing, Implementing, and Testing Mixed Reality and High Interaction Media Applications in Schools. *Proceedings of CELDA 2005*. Porto, Portugal, pp. 123-130.

[9] Papert, S., 1980. *Mindstorms: Children, computers, and powerful ideas*. Basic Books, New York, USA.

[10] Robertson, J. and Good, J., 2004. Children's Narrative Development through Computer Game Authoring. *Proceedings of IDC 2004: Building a Community.* Maryland, USA, pp. 57-64.

[11] Rogers, Y. et al, 2005. Ubi-learning Integrates Indoor and Outdoor Experiences. *Communications of the ACM*, Vol. 48, No. 1, pp. 55-59.

[12] Sharples, M. et al, 2002. The Design and Implementation of a Mobile Learning Resource. *Personal and Ubiquitous Computing,* Vol. 6, pp 220-234.

[13] Terrenghi, L. et al, 2004. Design of an Interface for Technology Supported Collaborative Learning – The RAFT Approach. *Proceedings of ICEC 2004*, Eindhoven, The Netherlands, pp. 522-525.

[14] Winkler, T. and Herczeg, M., 2005. Pervasive Computing in Schools – Embedding Information Technology into the Ambient Complexities of Physical Group-Learning Environments. *Proceedings of the SITE Conference 2005*. Norfolk, USA, pp. 2889-2894.