Social Interactions of the Collaborative Problem Solving in a Mobile Learning Environment

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Abstract: - We have investigated collaborative problem solving in a teaching experiment , which was organized for 8 fifth grade pupils in the collaborative problem solving learning environment in a botany park. The participating teacher was trained by us and pupils had available kits, interfaces and Tablet PCs equipped with Microsoft Office PowerPoint 2003 program and 3G wireless technology. Pupils activities were video recorded and the analysis proceeded through writing video protocols, edited into episodes and then classified into categories. Categories were mainly derived empirically. In the analysis, we used concepts such as collaboration and problem solving,in accordance with social constructivism. The data showed that typical learning processes were collaborative (48% of all episodes) as well as dynamic problem-solving processes, inseveral stages. Pupils worked quite independently of the teacher, as they learned to use the Tablet PC with 3G wireless technology autonomously in their technology projects. It appears, however, that more teacher support, such as introducing handbooks, planning tools and advanced working skills, would have been an advantage. And it also appears the non-group interations would provide help in the problem solving process.

Key-Words: - Collaborative learning, Mobile Learning, Social Interactions, Problem Solving

1 Introduction

New technology offers the opportunity for children and adults to communicate with teachers and fellow learners around the world, to interact with rich learning resources and simulated environments, to call on information and knowledge when needed to solve problems and satisfy curiosity, and to create `personal learning narratives' through an extended process of capturing and organising situated activity[12]. A number of varieties of mobile technologies suitable for training and education may be recognized:interaction with learning materials via a detached device (such as a laptop or PDA) physically connected to the network, wireless WANs (Wide Area Networks), PANs (Personal Area Networks) that allow the creation of ad hoc networks, WAP (Wireless Application Protocol) phones, pocket PCs, palmtops and other devices. The specific type of device which is used for mlearning services is basically irrelevant as long as it is wireless [7].

In this paper we examine the potential of a Mobile learning environment, designed to promote problem solving in small groups and where a the Tablet PC with 3G wireless technology is utilised. Our technology project course was popular in elementary school. We used a xoops web site to show the imformation about our project, Microsoft Office PowerPoint 2003 tools, and Tablet PC with 3G wireless technology interface as necessary software and hardware for problem-solving activities. To support teachers in their efforts to develop technology education, we have written handbooks and organized in-service training.

Third generation (3G) networks were conceived from the Universal Mobile Telecommunications Service (UMTS) concept for high speed networks for enabling a variety of data intensive applications [1]. The dream of 3G is to unify the world's mobile computing devices through a single, worldwide radio transmission standard. Imagine being able to go anywhere in the world secure in the knowledge that your mobile phone is compatible with the local system, a scenario known as "global roaming" [2].

A tablet PC is a notebook- or slate-shaped mobile computer. Its touch screen or digitizing tablet technology allows the user to operate the computer with a stylus or digital pen, or a fingertip, instead of a keyboard or mouse. The form factor offers a more mobile and productive way to interact with a computer. The tablet PC is a culmination of advances in shrinking notebook hardware and improvements in integrated digitizers as methods of input. A digitizer is typically integrated with the screen, and correlates physical touch or digital pen interaction on the screen with the virtual information portrayed on it. A tablet's digitizer is an absolute pointing device rather than a relative pointing device like a mouse or touchpad. A target can be virtually interacted with directly at the point it appears on the screen. Tablet PCs are often used where normal notebooks are impractical or unwieldy, or do not provide the needed functionality [15]. In this paper, we use Tablet PC with 3G wireless technology (upload 128kbps / download 384kbps) to be a mobile-learning device.

The use of Handhelds was ubiquitous for all the children, and the voice synthesis in the platform supported the reinforcement of visual messages [5]. Social constructivism was chosen as a framework relevant to the topic of the present paper, although we recognize the general critique on constructivism. Within a selected social-constructivist perspective, we are interested in finding how problem solving is experienced socially, with a shared social experience and social negotiation. In practice, we examine the potential of the Tablet PC with 3G technology tool to promote problem solving in small groups, during technology projects where the formal teaching of programming does not occur. Therefore, we are also interested in how our software and hardware can support pupils collaboration and what the teacher's role is when she or he supports this collaboration in the moblie learning environments.

Characteristic of effective problem solving is a process, which consists of different stages. These include: identifying and formulating the problem; recognising and finding the facts related to the problem; setting the goals; generating alternatives (possible solutions); evaluating the alternatives and choosing the best one(s); implementing the chosen solution (building up a model/article/program); testing and evaluating it; determining if the problem is solved; and modifying the solution if necessary [4] [11] [6]. A creative problem solving process is not linear and does not follow any strict pre-determined rules, because rational approaches miss the whole point of creativity. Such a process is most often iterative or dynamic, and contains a number of feedback loops to the basic outline [14]. Problem solving in small groups appears to provide additional benefits to problem-solving processes, as well as to learning [9] [10].

It is obvious that classroom based research is needed to explore the role of a programming tool in facilitating pupils' collaborative problem solving within micro chip activities. This is important, if we wish to develop present learning environments further and facilitate pupils' collaboration in micro chip activities, such as programming, planning and evaluating.Our aim is to characterise the nature of collaboration and the components of the learning environment, which can foster or obstruct it [3].

We want to evaluate the nature of pupils' collaborative problem-solving processes in the mobile learning environment in which the software and hardware developed in the technology project are used. New ideas for further development of the mobile learning environment and the Tablet PC with 3G technology tool are also needed. The following questions directed this study.

1. What is the nature of pupils' collaborative problem-solving activities in the technology projects learning environment where Tablet PC with 3G wireless technology tools are utilised?
2. What is the teacher's role in the mobile learning process?
3. What is the non-group pupil's role in the mobile learning process?

2 The Empirical Study

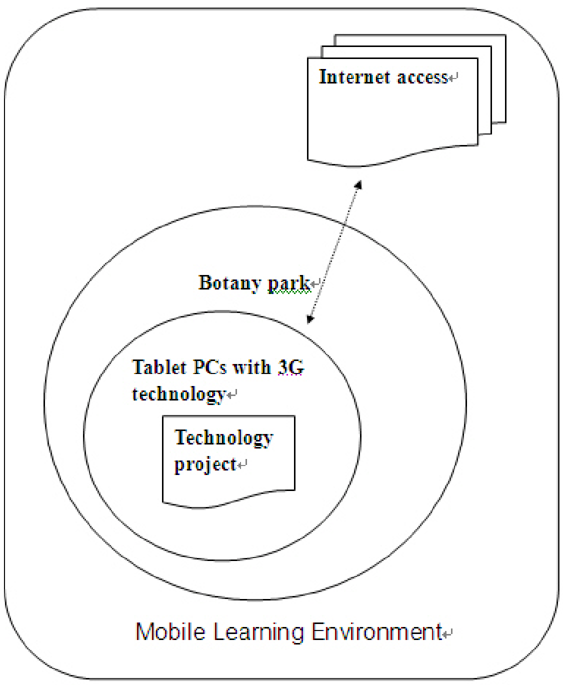
Our research can be described as a case study in which data are gathered by observations recorded in a field diary and videotaped recordings to analyse the pupils' collaborative problem solving during the technology project activities. Naturally, such an approach does not allow any broad generalizations to be made.

2.1 Teaching experiment

A teaching experiment was organized in winter 2006 in a botany park near the elementary school. A total of 8 pupils and one technology-education teacher participated in the experiment. The course was an elective one, so the pupils had selected it from a range of options offered by the school. The pupils were divided into two separate groups, each of which was working in pairs with the technology projects activities described below for 16 hours, four hours a day. The teacher assigned the pairs randomly. In the classroom there were 2 computers (Tablet PCs with 3G technology) with internet access. All pupils had used the computer before. The technology projects theme was new to all pupils.

During the first 4 hours of the teaching experiment, the key principles of making the connections with technology projects, as well as the basic ideas of working with program tools by using Tablet PCs with 3G wireless technology, were introduced to the pupils. The teacher talked with pupils and demonstrated how they were expected to work in pairs within the projects. Pupils learned to use the software during problem-solving projects, which were organized during the next 8 hours. Pupils had the opportunity to seek information in the guidebook during the project work. During the last 4 hours of the teaching experiment in a botany park, the pupils carried out their 'own project', which involved setting the problem, planning, generating alternatives (composing), and constructing the structure of the system and the program, as well as evaluating the product.

Fig.1, The concept map for pupils use the Tablet PC with 3G wireless technology in their technology projects.



The mobile learning of content (the basics of technology projects) on the one hand, and problem solving skills, including identifying and specifying the problem and developing ideation skills, on the other, were somewhat rivalling of importance. This was the case especially during the middle phase of the course. Furthermore, projects were designed to familiarise the pupils with the basic stages of problem solving.

From the point of view of programming, the pupils became familiar with digital input and output and the if-command during that project. From the point of view of problem solving, the pupils had to specify the problem, find facts and resources (needed in programming and model building), plan the project and generate possible solutions, construct the program and build the model, evaluate the model, and test the program (debug). In practice, both identifying the problem, and generating and evaluating alternatives were missing from the problem-solving processes almost entirely. Problem-solving processes were cut short, since the pupils had to learn programming and basic technological processes.

2.2 Data collection

The field notes include facts as date, time and general circumstances, as well as observations about the pupils' and teacher's behaviour, and discussions during, before and after the videotaped periods. Video recording was the main data collection method, the activities of the pupils can be observed more than once [13].The recordings were carried out in the middle of the teaching experiment, when pupils worked on small teacher-set tasks. The recording was made from the beginning of the lesson and stopped after about 91 minutes. Consequently, we recorded a total of 6 hours and 5 minutes of pupil activities. The videos include all kinds of pupil and teacher activities, e.g., the teacher's short instructions in the beginning of the lesson and even incoherent behaviour of pupils. 4 Camcorders (HDDV) were placed so that simultaneously the computer screen as well as both pupils discussing could be seen while constructing the model.

2.3 Data analysis

2.3.1 Verbatim

The review of the purpose of this study preceded our data analysis. We needed to describe both pupils' collaborative problem-solving processes, and the teacher's role in them. After the review, the researchers read the field notes, viewed the videotapes twice and discussed preliminary findings. The 'field researcher' (the one who had been present when the videorecording took place) transliterated all verbal and non-verbal events on the videos. He played and replayed them at least four times, focussing on writing down verbatim all natural talk between the pupils and between the pupils and the teacher. Another researcher confirmed the notes on the basis of the video recordings. This displayed data helped us to see patterns and led us to develop explanations, definitions of criteria for categories in further analysis, as well as more differentiated text, based on the videos and field notes [16].

2.3.2 Descriptions of the Categories

Using the research questions as initial guides allowed us to search for the data for broad categories. The analysis began with two broad categories that reflected the primary focus of the study: stages in the problem-solving process and pupils' collaborative social interaction during the problem solving activities. We used categories derived from our theoretical background as well as categories concluded by induction from the field and video notes. The main and sub categories, their definitions and examples from the notes typical of the categories are presented in Tables I and II. The field researcher wrote descriptions of the categories. The second researcher read the definitions focusing on the extent and independence of the categories in reference to the video notes. The descriptions were specified and refined on the basis of discussion between these two researchers.

Table.1, Descriptions of the categories of tasks in problem-solving activities. An activity can be that of a pair, of pupil(s) and their teacher or of between non-group.

Problem-solving task		**Description of the category**
Problem . . .	**P1**	
Identifying	**P11**	A problem of the whole project is identified or a problem during programming or model building is identified.
Formulating	**P12**	The problem is formulated, shaped or defined.
Specifying	**P13**	The problem is specified or restricted or an attempt is made to understand what the problem is.
Recognizing and finding . . .	**P2**	
Facts	**P21**	Facts or ideas related to the problem are looked at in nongroup resources (the pupils read the manual or handbook or ask other groups or the teacher for help)
Resources	**P22**	Building blocks, wires and sensors needed in the project are sought.
Planning . . .	**P3**	
Whole project	**P31**	The whole project is planned, goals or visions for solving the problem are set.
Programming	**P32**	How to modify a program or how to add a single command to the program structure is planned.
Model building	**P33**	How to modify a construction or how to add a block to the construction is planned.
Alternatives . . .	**P4**	
Generating	**P41**	An original and new idea is generated.
Evaluating	**P42**	The idea is evaluated.
Constructing	**P5**	
Programming	**P51**	An icon is selected or placed in the flow chart; a dialogue box is opened, a parameter is modified, a program is opened or saved or a set up of the program is prepared.
Model building	**P52**	A model is constructed or an idea is put to practice (a building block is selected, blocks are combined, a sensor is connected to the interface, a lamp or a motor is connected to the interface or the interface is connected to the computer).
Evaluating	**P6**	
Testing model	**P61**	The model/construction is evaluated without executing the program.
Debugging	**P62**	The system (program and model) is evaluated by executing the program with the aim to develop it further. While the program is executed, the pupils may watch the technology projects.

The coding was revised by comparing the codes to the pupil's behaviour as seen in the videos. The videos were viewed played and rewound with the aim of making the coding reliable. A second researcher who took part in the description process of the categories, used the same descriptions of the categories and the same coding process for randomly-selected samples, 20% of the total collected protocols. The two coders reached a 78% consensus on coding the episodes. Disagreement was not systematic and equally frequent in the main categories P and I.

The third researcher later classified a few randomly selected periods of the protocol. He did not take part in the above-mentioned discussion process, where descriptions were specified and modified. Consequently, he used only written descriptions of the categories in his work, referring more to the video recordings than to the written protocols. The compatibility between the classifications of the first and third researchers was high. Almost full consensus on coding the episodes was possible in all cases that could be thoroughly analysed in detail [8].

Table.2, Descriptions of the categories of the pupils' social interaction during problem-solving activities.

Type of social interaction		**Description of the category**
Pupil-pupil interaction	**I1**	Collaborative interaction occurs in a small group
Democratic	**I11**	Pupils talk and work together to produce a single outcome, to set goals, to make decisions, to solve problems, to construct, program and modify solutions and evaluate the outcomes through dialogue.
Domineering	**I12**	One pupil gives an order to another pupil, staggers an idea of another or works in a way that causes another pupil to withdraw while they are working together.
Pupil-teacher interaction	**I2**	Social interaction occurs between the teacher and the pupil(s)
Direct guidance	**I21**	The teacher says or shows how to find resources, to plan, build a model, select a command or parameters in a dialogue box or execute the program.

Pupils ask questions	**I22**	Pupils ask the teacher questions looking for help in recognizing facts or resources, planning, programming, building or debugging.
Between non-group interaction	**I3**	Social interaction occurs between non-group
Other group visit	I31	The pupil of other group come to visit our project or ask something about programming
To visit other group	I32	Pupil go to visit other group's project or ask them something about programming

3 Results

The frequencies of each category defined in the previous Chapter are presented in the matrix of Table III. Data were acquired in accordance with qualitative methodology and, therefore, were not intended for quantitative analysis. The main emphasis was on the interpretations drawn from primary data sources. It is possible, for example, to see in Table III what kinds of social interaction are typical at each stage of problem solving.

Typical of pupils' collaborative problem solving activities were programming (10% of all episodes), debugging (7%) and planning together through democratic dialogue (7%). This third type of activity was mostly to add a single command to the program or to fix a new item in the model. We see that identifying, formulating and specifying the problem (10%) and generating alternatives or evaluating them (2%) alone, together or with the teacher's help(4%) .

Table.3, The frequencies of each category based on the descriptions presented in Table I and II.

Task in problem solving	**Social Task in problem solving interaction**							
	I11	I12	I21	I22	I31	I32	Total	Total
P11	2	1					3	
P12	1	1					2	11
P13	2	2		1	1		6	
P21	8		1	1	5		15	24
P22	6			1	2		9	
P31	2	1					3	
P32	5	2	1	1		2	11	18
P33	1		3				4	
P41	1	1					2	4
P42	1	1					2	
P51	12	7	3	4	5	4	35	47
P52	7	2	1	1	1		12	
P61	4	2					6	11
P62	4	1					5	
Total	56	21	9	9	14	6		115

This field experiment nicely demonstrated pupil-centred activities. The most common social activity was of the nature of pupil-pupil interaction. In 67% of all episodes pupils talk and work together to produce a single outcome, to set goals, to make decisions, to solve problems, to construct, program, or modify solutions, or evaluate the outcomes through a dialogue. In summary, classification of episodes and frequencies of those episodes indicate that, in the technology projects learning environment where the technology projects programming tools are utilised, the pupils were extremely active in problem solving. The teacher had taken the role of a tutor asking questions, which means clarifying the pupils' ideas. The strong motivation can also be explained by several different factors. The elective nature of the course affects motivation, but the task-oriented collaborative approach and the equipment and moodle web site and programming tools used might also tend to strengthen motivation. And the non-group interations would provide an solution model to help pupils when they were programming and debugging. in the problem solving process . The non-group pupils had taken the role of a reference object, when the pupil encounters the difficulty in the problem solving process.

4 Conclusion

To conclude, as the study focussed on the pedagogical nature of the mobile learning environment, this section summarises the main results and discusses the mobile learning processes of the pupils. We propose that there are sound reasons to believe that handheld devices (Tablet PC with 3G wireless technology) will have a role to play in the way we learn. The extent to which this opportunity will be taken will depend on how the technology is used. From our analysis of the current mobile learning research and applications, as well as our own experience with developing Tablet PC with 3G wireless technology applications. A few instructional implications or implications to organize the mobile learning environment will then be derived and even some suggestions for future development of the mobile learning environment offered. As a summary of our theoretical framework of problem solving, we claim that creative problem solving has different stages and is enabled by language (occasioned through social interaction and mediated through control-technology activities), and the stages of the process are dynamic.

When collaborating, the pupils worked and discussed problems relevant to their work, striving to achieve common goals. There were obvious differences in the nature of collaboration between the various video-recorded sessions. The pupils were free to decide their tasks in teams. They were also encouraged to switch or change the tasks now and then. In planning the activities, it was important to remember that pupils do not spontaneously produce collaboration, creative solutions and effective planning [16], as well as pupils finished their projects in the classroom.

Although the pupils easily evaluated in their projects, how the program or Tablet pc works, they did not as easily discover ways to develop the work process. We want to emphasise, however, that pupils should even evaluate the whole process as well as collaboration. The make a idea in how collaboration is supported between teacher and non-group interaction, due to the use of handheld devices that offer a manageable solution for the coordination, communication and interactivity, which is possible on Tablet PCs with 3G wireless technology, plus the participants' mobility. Also, projects activities manage and encourage tasks that include: (a) organization of information, (b) enabling pupils to collaborate in groups, (c) monitoring real-time progress with respect to learning objectives and (d) controlling the interaction, negotiation, coordination and communication. Tablet PCs with 3G wireless technology are emerging as a flexible and portable solution that provides pupils with ‘‘at hand’’ support to engage in collaborative activities anytime, anywhere.

Consequently, different kinds of activities with pupil collaboration, or instructional strategies based on pupil collaboration, are needed [9]. We suggested above some approaches for developing study processes in a mobile learning environment further. It will be interesting to see whether these principles can be put into practice. We are continuing our efforts in several related projects base on mobile learning.

References:

[1]*3G Standards*. 3G Phones. Retrieved January 29, 2007, from the World Wide Web: http://www.three-g.net/3g_standards.html

[2]*3G Introduction*. MobileIN.com. Retrieved January 29, 2007, from the World Wide Web: http://www.mobilein.com/3G.htm

[3]Barak, M., Maymon, T. & Harel, G., Teamwork in Modern Organisations: Implications for Technology Education, *International Journal of Technology and Design Education*, Vol.**9**, No.1, 1999, pp. 85–101.

[4]De Luca, V. W., Survey of Technology Education Problem-Solving Activities, *The Technology Teacher*, Vol. 51, No. 5, 1993, pp. 26–30.

[5] Gustavo Zurita, Miguel Nussbaum, Computer supported collaborative learning using wirelessly interconnected handheld computers, *Computers & Education* , Vol.42. 2004, pp. 289–314.

[6]Higgins, J. M., *101 Creative Problem Solving Techniques: The Handbook of New Ideas for Business*, New Management Publishing, Winter Park FL., 1996.

[7] Ing. Robert J. Wierzbicki., Emerging Issues in m-Learning, *WIERZBICKI.ORG eLearning Solutions*, Erlangen, Germany, 2003.

[8]Jari, L., Veijo, M. & Matti, L., Collaborative Problem Solving in a Control Technology Learning Environment, a Pilot Study, *International Journal of Technology and Design Education*, Vol.12, 2002, pp. 139–160.

[9]Johnson, S. D. & Chung, S.-P., The Effect of Thinking Aloud Pair Problem Solving (TAPPS) on the Troubleshooting Ability of Aviation Technician Pupils, *Journal of Industrial Teacher Education* , Vol.37, No.1, 1999.

[10]Johnson, D. W. & Johnson, R. T., *Learning Together and Alone: Cooperative, Competitive, and Individualistic Learning* (4th Ed.), Allyn & Bacon, Needham Heights, MA. 1994.

[11]McCormick, R., Murphy, P. & Hennessy, S., Problem-solving Processes in Technology Education: A Pilot Study, *International Journal of Technology and Design Education*, Vol.4, No.1, 1994.

[12]Mike Sharples,The design of personal mobile technologies for lifelong, *Computers & Education* , Vol.34 , 2000, pp177-193.

[13]Savenye, W. C. & Robinson, R. S., Qualitative Research Issues and Methods: An Introduction for Educational Technologists, in R. Jonassen (ed.), *Handbook of Research for Educational Communications and Technology. A Project of the Association for Educational Communications and Technology (AECT)*, Prentice Hall International, London, 1996, pp. 171–1195.

[14]Welch, M., Analyzing the Tacit Strategies of Novice Designers, *Research in Technology & Technological Education*, Vol.17, No.1, 1999, pp. 19–35.

[15] *Tablet PC*. Wikipedia.org. Retrieved January 29, 2007, from the World Wide Web: http://en.wikipedia.org/wiki/Tablet_PC

[16]Yang, H.J. , Yang, H.H., Wang, C.C. & Huang, K.Y. Social Interactions of The Computerized Collaborative Problem Solving on Micro Chip, *Proceedings of the WSEAS Conferences: 5th WSEAS International Conference on APPLIED Computer Science (ACOS '06)*, Hangzhou, China, April 16-18, 2006.