Proceedings of the 5th WSEAS International Conference on Applied Computer Science, Hangzhou, China, April 16-18, 2006 (pp227-233)

Social Interactions of the Computerized Collaborative Problem Solving on Micro Chip

Hung-Jen Yang, Hsieh-Hua Yang*, Cheng Chung Wang, Kuo-Yan Huang
Department of Industrial Technology Education
National Kaohsiung Normal University
No. 62, Shenjhong Rd., Yanchao Township, Kaohsiung County 824, Taiwan
Republic of China

*Department of Health Care Management
Chung Jung Christian University
396 Chang Jung Rd., Sec. 1, Kway Jen, Tainan 71101, Taiwan
Republic of China

Abstract: - We have investigated collaborative problem solving in a teaching experiment, which was organized for 32 senior university students in the computerized collaborative problem solving learning environment. The participating teacher was trained by us and students had available kits, interfaces and computers equipped with 8051 micro chip programming tools. Student 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 (51% of all episodes) as well as dynamic problem-solving processes, inseveral stages. Students worked quite independently of the teacher, as they learned to use the programming tool autonomously in their technology projects. It appears, however, that more teacher support, such as introducing handbooks, planning tools and advanced programming skills, would have been an advantage. And it also appears the non-group interations would provide help in the problem solving process . Some ideas about further development of study processes in modern learning environments are discussed.

Key-Words: - **C**ollaborative learning, Computerized, Social Interactions, Problem Solving

1 Introduction

In this paper we examine the potential of a learning environment, designed to promote problem solving in small groups and where a the computerized programming tool is utilised. Our project 8051 micro chip course was popular in university. We used a moodle web site to show the imformation about our project, micro chip programming tools, and the COM I/O 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.

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 programming tool to promote problem solving in small groups, during micro chip projects where the formal teaching of programming does not occur. Therefore, we are also interested in how our software and hardware can support students collaboration and what the teacher's role is when she or he supports this collaboration.

A learning process in a learning environment can be considered a problem solving activity [20]. Problems and problem solving have been defined in many ways in the technology education context [12]. In this study, what is meant by problems are the ill-defined and multi-faceted real-world problems that are sought and identified in the environment. Real-world problems motivate and should help to encourage the transfer of knowledge and skills by allowing students to put their knowledge to use [15]. 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 [3] [13] [5]. 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 [2] [21]. Problem solving in small groups appears to provide additional benefits to problem-solving processes, as well as to learning [14] [8] [9].

A common feature of ways of how to emphasise creative problem solving in technology education is to place students in the midst of realistic, vaguely defined, complex and meaningful problems, with no obvious or 'correct' solutions [10]. For example, Sellwood [17], De Luca [4] as well as Williams and Williams [22] argue that problemsolving activities are an integral part of design and technology education, in contrast to instruction-following design and technology, reproducing articles and teacher-dominated work. On the other hand, students often omit essential stages of problem-solving processes, such as planning and ideation. Moreover, stages such as testing and evaluation are evident but are not used in the technology education context as described in problem-solving models [21].

It is obvious that classroom based research is needed to explore the role of a programming tool in facilitating students' collaborative problem solving within micro chip activities. This is important, if we wish to develop present learning environments further and facilitate students' 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 [1].

We want to evaluate the nature of students' collaborative problem-solving processes in the micro chip learning environment in which the software and hardware developed in the micro chip LED project are used. New ideas for further development of the learning environment and the programming tool are also needed. The following questions directed this study.

1. What is the nature of students' collaborative problem-solving activities in the 8051 micro chip learning environment where micro chip programming tools and moodle web site are utilised?
2. What is the teacher's role in the learning process?
3. What is the non-group student's role in the 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 students' collaborative problem solving during micro chip activities. Naturally, such an approach does not allow any broad generalizations to be made. However, this restriction was accepted at this exploratory stage of the research process [18].

2.1 Teaching experiment

A teaching experiment was organized in winter 2005 in a university. A total of 32 students and one technology-education teacher participated in the experiment. The course was an elective one, so the students had selected it from a range of options offered by the school. The students were divided into three separate groups, each of which was working in pairs with the 8051 micro chip activities described below for 16 hours, four hours a day. The teacher assigned the pairs randomly. In the classroom there were 12 computers (PC, P43.0 processors) with internet access, the 8051 micro chip and a guidebook:8051/8951 Micro Chip [19]. All students had used the computer before. The 8051 micro chip theme was new to all students.

The male teacher, who had long micro chip teaching experience1 was trained to use the moodle web site and he became familiar with the interface of the moodle web site as well as the users' guide. Before the teaching experiment he had been in contact with one of the researchers concerning the conduct of the experiment.

During the first 4 hours of the teaching experiment, the key principles of making the connections with 8051 micro chip, as well as the basic ideas of programming with programming tools, were introduced to the students. The teacher talked with students and demonstrated how they were expected to work in pairs within the projects. Students learned to use the software during problem- solving projects, which were organized during the next 8 hours. Students had the opportunity to seek information in the guidebook during the project work. During the last 4 hours of the teaching experiment, the students 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 interface of the moodle web site.

The learning of content (the basics of 8051 micro chip and programming) 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 students with the basic stages of problem solving.

From the point of view of programming, the students became familiar with digital input and output and the if-command during that project. From the point of view of problem solving, the students 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 students had to learn programming and basic technological processes.

2.2 Data collection

The field notes were written in the classroom and completed immediately after the school visits. The notes include facts as date, time and general circumstances, as well as observations about the students' 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 students can be observed more than once [16]. We have field notes and videos from three different groups. One of the researchers, together with the teacher, selected a typical pair to monitor. Such a pair had usually succeeded in their activities, with limited teachers' guidance. The recordings were carried out in the middle of the teaching experiment, when students worked on small teacher-set tasks. The recording was made from the beginning of the lesson and stopped after about 55 minutes. Consequently, we recorded a total of 2 hours and 48 minutes of student activities. The videos include all kinds of student and teacher activities, e.g., the teacher's short instructions in the beginning of the lesson and even incoherent behaviour of students. A Camcorder (DV) was placed so that simultaneously the computer screen as well as both students discussing could be seen while constructing the model. Even student discussions can be heard on the tapes. The field diary and the videotapes were the 'rough data' for analysis focussed on phenomena relevant to the study questions.

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 students' 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 students and between the students and the teacher. These notes covered 22 standard pages. 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 [19].

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 students' 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.

The coding was revised by comparing the codes to the student'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

Proceedings of the 5th WSEAS International Conference on Applied Computer Science, Hangzhou, China, April 16-18, 2006 (pp227-233)

categories and the same coding process for randomly-selected samples, 10% of the total collected protocols. The two coders reached a 75% consensus on coding the episodes. Disagreement was not systematic and equally frequent in the main categories P and I.

Table.1, Descriptions of the categories of tasks in problem-solving activities. An activity can be that of a pair, of student(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 students 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 students may watch the movement of the LED lights on the 8051 micro chip.

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.

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

Type of social interaction		Description of the category
Student-student interaction	**I1**	Collaborative interaction occurs in a small group
Democratic	**I11**	Students 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 student gives an order to another student, staggers an idea of another or works in a way that causes another student to withdraw while they are working together.
Student-teacher interaction	**I2**	Social interaction occurs between the teacher and the student(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.
Students ask questions	**I22**	Students 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 student of other group come to visit our project or ask something about programming
To visit other group	I32	Student 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 students' collaborative problem solving activities were programming (11% of all episodes), debugging (11%) and planning together through democratic dialogue (5%). 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 (6%) and generating alternatives or evaluating them (2%) alone, together or with the teacher's help, happened far less frequently.

This field experiment nicely demonstrated student-centred activities. The most common social activity was of the nature of student-student interaction. In 51% of all episodes students 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 8051 micro chip learning environment where the 8051 micro chip programming tools are utilised, the students were extremely active in problem solving. The teacher had taken the role of a tutor asking questions, which means clarifying the students' 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 students when they were programming and debugging. in the problem solving process . The non-group students had taken the role of a reference object, when the student encounters the difficulty in the problem solving process.

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		1					1	
P12	1	1					2	7
P13	2	2					4	
P21	8		1	1	8		18	24
P22	6						6	
P31	1	1					2	
P32	4	2	1	1		2	10	16
P33	1		3				4	
P41		1					1	1
P42		1					1	1
P51	13	9	3	3	7	4	39	48
P52	7	2					9	
P61	10	3					13	26
P62	10	3					13	
Total	63	26	8	5	15	6		123

In a more detailed analysis of the raw data (not presented in the Table), we were able to draw further conclusions. During both programming and debugging, students frequently pointed to the screen, often simultaneously watching the LED lights and how the LED lights were on or off. While the students were planning the program or programming they pointed to the screen (program, with a finger or a mouse) 10 times (63% of all program planning episodes). We may interpret that the features offered by the 8051 micro chip were valuable for students when they were planning and debugging.

4 Conclusion

This article reports an attempt to stimulate collaborative problem solving in the learning environment where software and hardware, developed in the 8051 micro chip project, defined the physical nature of the learning environment. As the study focussed on the pedagogical nature of the learning environment, this section summarises the main results and discusses the learning processes of the students. A few instructional implications or implications to organize the learning environment will then be derived and even some suggestions for future development of the 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 students 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 students were free to decide their tasks (e.g., model building or programming) 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 students do not spontaneously produce collaboration, creative solutions and effective planning.

Although the students easily evaluated in their projects how the program or machine works, they did not as easily discover ways to develop the work process. We want to emphasise, however, that students should even evaluate the whole process as well as collaboration. The group achievements and the individual students' contribution to the collaboration and its achievements must be remarked on. It would be useful to develop a monitoring/ reporting tool (e.g., a questionnaire or portfolio) to keep groups focused and advancing in their planning, constructing and evaluating.

Consequently, different kinds of activities with student collaboration, or instructional strategies based on student collaboration, are needed [8]. Moreover, how to introduce problem-solving activities and all stages connected to a problem-solving process is not an easy task. In particular, problem posing, planning of the whole project and ideation are difficult phases to introduce to students [11]. Collaboration and problem solving are necessary in productive learning environments and need to be integrated into the technology education curriculum [7].

We suggested above some approaches for developing study processes in a modern 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.

References

[1]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.

[2]Barlex, D. M., Read, N., Fair, D. & Baker, C., *Deserting Starts Here*, Hodder & Stoughton, Sevenoaks, 1991.

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

[4]Hennessy, S. & Murphy, P., The Potential for Collaborative Problem Solving in Design and Technology, *International Journal of Technology and Design Education,* Vol.**9**, No.1, 1999, pp. 1–36.

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

[6]Huberman, A. M. & Miles, M., *Qualitative Data Analysis: An Expanded Sourcebook*, Sage, Thousand Oaks, CA., 1994.

[7]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.

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

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

[10]Lavonen, J., Meisalo, V. & Lattu, M., Problem Solving with an Icon Oriented Programming Tool, Journal of Technology Education Vol. 12, No. 2, 2001, pp. 33–47.

[11]Lewis, T., Petrina, S. & Hill, A. M., Problem Posing-Adding a Creative Increment to Technological Problem Solving, *Journal of Industrial Teacher Education* , Vol.**36**, No.1, 1998.

[12]McCade, J., Problem Solving: Much More Than Just Design, *Journal of Technology Education,* Vol. **2**, No.1, 1990.

[13]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.

[14]Parker, G.M., *Team Players and Teamwork: the Competitive Business Strategy*, Jossey-Bass, San Francisco,1991.

[15]Resnick, L., Learning in School and Out, *Educational Researcher*, Vol.16, No.9, 1986, pp. 13–20.

[16]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.

[17]Sellwood, P., The investigative Learning Process, *The Journal of the Design & Technology Teaching* Vol.24, No.1, 1991, pp. 4–12.

[18]Strauss, A. & Corbin, J., *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*, Sage Publications, Thousands Oaks, CA., 1990.

[19]Tasy, C.Y., *8051/8951 Micro Chip :BASIC Version*, Chwa, Taipei, 2004.

[20]Voss, J. F., Learning and Transfer in Subject-matter Learning: A Problem-solving Model, *International Journal of Educational Research*, Vol.11, 1987, pp. 607–622.

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

[22]Williams, A. & Williams, J., Problem Based Learning: An Appropriate Methodology for Technology Education, *Research in Science & Technological Education*, Vol.15, No.1, 1997, pp. 91–103.