The Technology Fair as means for enhancing problem solving skills and interest in Science and Technology

Alexandros C. Mettas and Constantinos P. Constantinou
Learning in Science Group, University of Cyprus,
P.O. Box 20537, Nicosia 1678, CYPRUS
Tel 357-2753758, Fax 357-2753702
Email: mettas@ucy.ac.cy, c.p.constantinou@ucy.ac.cy

Abstract. *This paper presents the idea of using the Technology Fair as a means for promoting students' problem solving skills. The purpose of the study was to investigate the influence of a procedure of working with primary school children to complete and present a Technology Fair project, on the problem solving skills of undergraduate students. Pre-tests and post-tests were administered to undergraduate students before and after the preparation of the Technology Fair, respectively. A number of students were selected and interviewed after the completion of the technology fair. Data were also collected from reflective diaries kept by the students during the preparation of the technology fair. The analysis of the results indicates that the Technology Fair contributes to the development of positive values and attitudes in science and technology education and has a significant influence on improving students' understanding and application of problem solving and decision making strategies within the domain of technology.*

Keywords. Decision Making, Design and Technology, Problem-Solving, Technology Fair.

1. Introduction

Science Fair projects have long been used as a mechanism for promoting scientific skills with an emphasis on learning through "doing". Identifying problems, formulating questions, making observations, proposing solutions, and interpreting data are necessary skills for students in school and throughout their lives. The type of education that places emphasis on these skills through hands-on science activities can simultaneously promote understanding of fundamental principles in science [3] [5].

The Technology Fair is a new idea derived from Science Fair projects that have been taking place for many years by the Learning in Science Group, University of Cyprus. Technology Fair initiatives encourage students to explore their technical environment in a systematic manner. The underlying principle is that participation in a Technology Fair stimulates students' interest in science and technology while simultaneously promoting the development of technological problem solving and decision making as important life skills. In this paper we present a preliminary study of an initiative to integrate the Technology Fair in the context of an elementary teacher preparation program.

2. Theoretical Background

Science and technology education share a commitment to teaching process, scientific method in science, design in technology and problem solving in both areas. Teaching students how to solve problems is an important goal of education.

Problem solving strategies hold a special importance in education. Many tasks performed in professional and daily life require such strategies, which we define as planned sequences of activities leading to a goal which is the solution to the problem. Examples of such tasks are: writing an informative text, designing a product, solving a management problem or a technical or scientific problem. Much research has been carried out into problem solving, analyzing and describing strategies for solving different types of problems, designing instruction and/or training for chosen strategies, and measuring the result of teaching interventions [1].

Problem based learning is an instructional approach that has already been at least implemented on a trial basis in elementary and secondary education [4]. The problem acts as the stimulus and focus for student activity and learning [1]. Learning in this way is purposeful and self-sustaining as the student learns while searching for solutions to the problems they have formulated themselves. Students are actively involved and learn in the context in which knowledge is to be used.

First versions of teaching approaches in relation to problem solving sometimes rely heavily on practicing problem solving on a large number of problems. Instruction and feedback are usually focused on the sequence of problem solving steps to be performed and less emphasis is placed on the knowledge and the cognitive strategies necessary to perform these steps. In the 1980s, researchers introduced new methods of instruction composed of a wider variety of learning tasks. Some of these were based on new insights into cognitive processes. Many of these approaches are inspired by theories on the role of schemata in domain knowledge [6] or by theories on mental models [2]. Recently, more emphasis has been placed on the use of computers and modern information and communication technology (ICT) in the teaching of problem solving and on peer collaboration [7], whereas cognitive psychology has produced new perspectives such as multiple-code theories and connectionist models [10].

Thus, a wide variety of promising instructional approaches is available to teachers, instructional designers, and researchers. However, a more systematic overview of the merits of
the various approaches in terms of learning outcomes achieved in experimental settings is needed as a basis for the application of new methods of instruction [11].

Problem solving and technological developments have much in common. Technologies have historically given solutions to many of the problems people encounter. Problem solving activities provide students with opportunities to create and evaluate designs and to experience knowledge seeking, processing, and applications.

Problem solving activities implemented in technology education expand the opportunities for students. They teach students how to think, make decisions, and apply knowledge learned from experiences in and out of school. It is important for prospective primary teachers to develop this important instructional component.

To develop problem solving skills, students, through practice, must apply problem solving and thinking techniques to solve real problems. Students must merge the content of problem solving and the content of technology and integrate technical skills and problem solving skills. Technology Fair projects provide an opportunity for interaction between undergraduate student teachers and elementary school students so that they can work as a team with shared but different goals: The child aims to solve a problem and present both the problem and the solution during the Technology Fair. The student – teacher aims to use the interaction as a medium for helping the child develop problem-solving skills through a systematic approach.

In the context of Design and Technology problem solving is generally achieved through a sequence of steps called the design process. Based on the work of various researchers [12][9]. Figure 1 presents is an overview of a Design Process that can be followed in almost any technological problem solving activity. While the process has been divided into a number of discrete steps or phases for purposes of clarity, in reality one tends to "jump" between steps as the ideas take shape and one develops the solution to the chosen problem.

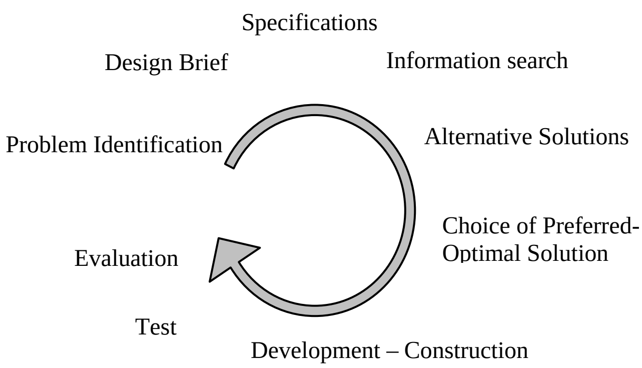

Figure 1. Design process

3. Purpose of the Research

The purpose of the study was to investigate the effectiveness of the Technology Fair in developing undergraduate students’ problem solving skills. More specifically, the purpose of the study was:

A. To examine whether the Technology Fair influences undergraduate students’ involvement and interests in technology

B. To improve our understanding of the processes used in developing technological problem solving and decision-making strategies and how the Technology Fair could contribute in this direction.

4. Research Design, Methods and Sample

The design of the research was based on the preparation and assessment of a technology fair. Primary school students with the assistance of university primary education students were responsible for identifying a human need, formulating a technological problem collecting information and developing an appropriate solution. Each university student was responsible for collaborating with one primary school student on a single technological project.

In this context, Technology Fair projects provide an opportunity for interaction between undergraduate student teachers and elementary school students so that they can work as a team with shared but different goals: the child aims to solve a problem and present both the problem and the solution during the Technology Fair; the student – teacher aims to use the interaction as a process for helping the child develop problem-solving and decision making skills through a systematic approach.

The Technology Fair was held with the cooperation of a local primary school in November 2004. During the fair, each student teacher displayed a poster describing the design process and the artifact they constructed. Additionally, the children engage the public in a specific aspect of their work through a specially design interactive exhibit. In order to assess their understanding about the design process, a number of tasks were selected and organized into pre-test, mid-test and post-tests. Tests were administered to students before and after the preparation of the technology fair, respectively (25/10/2004, 8/11/2004 and 29/11/2004). All tests included the same tasks.

In addition, each student teacher was asked to keep a detailed reflective diary after every meeting with the child. These diaries formed an additional source of data. In the diary each student teacher recorded all the information about difficulties they encountered and how they were able to overcome them. Additionally, teaching methods, emotions and ideas were reported after each meeting with the primary school student.

Following the completion of the technology fair 12 students were selected and interviewed about their experiences, problems and difficulties faced as well as their interest while working for the fair. Figure 2 shows graphically the design of the research.

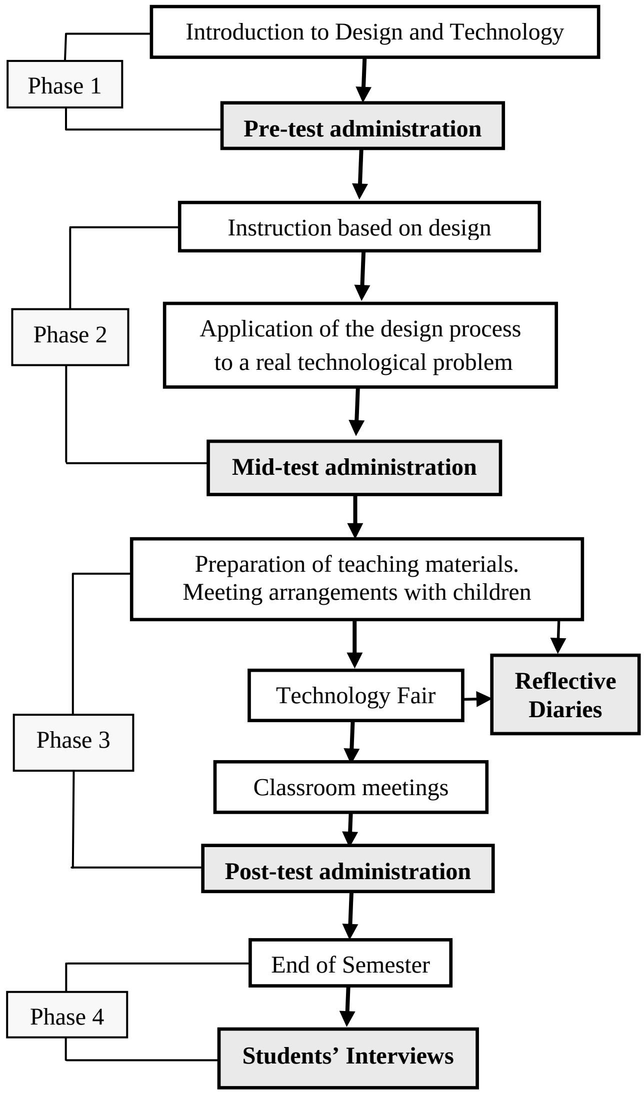

Figure 2. The research design

The sample of the research consists of 82 pre-service teachers at the Department of Educational Sciences, University of Cyprus. All pre-service teachers enrolled in a compulsory course on Design and Technology Education

5. Purpose of each Task in the Test

Eight tasks were designed to assess the understanding of pre-service teachers of the technological problem solving process

Task 1: Requires students to identify a need from the area of Transportation

Task 2: Requires students to formulate the Design Brief for a given problem

Task 3: Requires students to write the specifications and limitations for a given product (Bridge)

Task 4: Requires students to list a number of issues on which they need to seek information in order to be in a position to develop an appropriate solution

Task 5: Requires students to Draw/Sketch possible ideas/solutions for a given problem

Task 6: Requires students to choose a solution from a given table through an optimization process

Task 7: Requires students to Test and Evaluate a finished construction (bridge model)

Task 8: Case study - Requires pre-service teachers to prepare learning activities that take into account the technological problem solving process

6. Results

Responses to pre-tests, mid test and post-tests were analysed using the phenomenographic approach developed by [8].

The test consisted of 8 tasks that required understanding and implementation of the problem solving process in order to solve a new technological problem. The student responses to five of the tasks (task 2, 3, 4, 7, 8) are on an Interval Scale and will be analysed using the paired sample t-test. Three tasks (task 1, 5, 6) have responses on an Ordinal Scale and will be analysed using the Wilcoxon test. Tables 1-2-3 shos the results of the paired t-test for task 2, task 3, task 4, task 7 and task 8. Table 1 shows the comparison between pre-test and mid-test, i.e. the period from the introduction to the topic until the teaching and the implementation of the technological problem solving process. Table 2 shows the comparison between mid-test and post-test, i.e. the period before and after the Technology fair. Table 3 shows the comparison between pre-test and post-test, i.e. the effect of the overall intervention on pre-service teachers problem solving skills.

Table 1. Paired t-test comparing pre-test and mid-test

Task	Mean pre-test	Mean mid-test	t	d.f	p
Task 2	1,13	1,56	-3,84	81	,000
Task 3	3,09	3,39	-1,78	81	,078
Task 4	2,11	3,01	-5,18	81	,000
Task 7	1,21	1,39	-1,50	81	,136
Task 8	1,66	1,82	-1,01	81	,314

Table 2. Paired t-test comparing mid-test and post-test

Task	Mean mid-test	Mean post-test	t	d.f	p
Task 2	1,56	2,51	-9,55	81	,000
Task 3	3,39	6,24	-17,51	81	,000
Task 4	3,01	5,24	-12,19	81	,000
Task 7	1,39	2,54	-10,49	81	,000
Task 8	1,82	6,09	-25,63	81	,000

Table 3. Paired t-test comparing pre-test and post-test

Task	Mean pre-test	Mean post-test	t	d.f	p
Task 2	1,13	2,51	-11,88	81	,000
Task 3	3,09	6,24	-18,30	81	,000
Task 4	2,11	5,24	-19,50	81	,000
Task 7	1,21	2,54	-10,90	81	,000
Task 8	1,66	6,09	-22,81	81	,000

From table 1, we can see that pre-service teachers perform better in mid-test as compared to the pre-test, in task2 and task4. The differences are statistically significant for both task2 and task 4 with $t(81)=-3,84$, $p<0.01$ and $t(81)= -5,18$, $p<0.01$, respectively. There are no statistically significant differences between pre-test and mid-test performance for task 3, task 7 and task 8. From table 2 and table 3 it can be seen that there are statistically significant differences for all the tasks from mid-test to post-test and from pre-test to post-test.

Table 4. Wilcoxon test comparing pre-test and mid-test

	Task 1	Task 5	Task 6
	Mid– Pre	Mid– Pre	Mid– Pre
Z	-1,605(a)	-1,043(a)	-1,502(a)
Sig. (2-tailed)	,109	,297	,133

Table 5. Wilcoxon test comparing mid-test and post-test

	Task 1	Task 5	Task 6
	Post– Mid	Post– Mid	Post– Mid
Z	-5,244(a)	-5,587(a)	-4,310(a)
Sig. (2-tailed)	,000	,000	,000

Table 6. Wilcoxon test comparing pre-test and post-test

	Task 1	Task 5	Task 6
	Post– Pre	Post– Pre	Post– Pre
Z	-6,140(a)	-6,277(a)	-4,978(a)
Sig. (2-tailed)	,000	,000	,000

From the table 4 it can be seen that none of the differences between pre-test and mid-test are statistically significant for task1, task 5 and task 6. On the contrary table 5 and table 6 indicate that there are statistically significant differences for task1, task 5 and task 6 from mid-test as compared with the post-test ((Wilcoxon Z = -5,244, p<0,01, Wilcoxon Z = -5,587, p<0,01 and Wilcoxon Z = -4,310, p<0,01 respectively) and from pre-test to post-test (Wilcoxon Z = -6,140, p<0,01, Wilcoxon Z = -6,277, p<0,01 and Wilcoxon Z = -4,978, p<0,01 respectively).

7. Indications from students' Reflective Diaries and interviews

Almost every student (94%) characterized the opportunity to participate in the Technology Fair as a very important experience for their future teaching career, eg. a student stated in his reflective diary: "*my cooperation with the primary school pupil was very important for my future studies. I found myself improving my teaching skills*"

Students expressed the belief that at the end they were more confident in teaching the subject of Design and Technology in primary school, eg. a student said during his interview: "*After the Technology Fair I am feeling more confident to teach the subject of Design and Technology in primary school. It is very important to have this kind of teaching experience as part of our studies"*

A significant number of students express their positive dispositions and values gained through the Fair. They expressed the importance of hands on activities, the ability to transfer the knowledge and strategies used throughout the fair to other projects or areas of life. They also consider themselves to be more effective in identifying technological problems and to overcome possible obstacles that they might encounter in the process of teaching problem solving skills.

A great percentage (86%) of the students noted in their Reflective Diaries that primary school children worked through the design process with enthusiasm and positive attitude, eg. a student stated in his reflective diary: "*the pupil worked with enthusiasm during the design and construction of his project"*.

The overall process and the presentation of their work in the fair seem to enhance University and Primary school students' motivation and interest in the areas of Technology and Science, eg. a student said during her interview: "*The atmosphere during the Technology Fair was very stimulating for both pupils and students. My pupil showed an interest in every single project presented in the fair"*.

During the Technology Fair pre-service teachers expressed a number of emotions. Their initial emotions were characterized mainly by stress about the teaching process and about the interaction with pupils and their families. After the first meeting students showed different and substantially more positive emotions, eg. a student said during her interview: "*During my first meeting with the pupil I was very stressed. I was worried about the cooperation with the* *pupil. At the end of our meetings I was really happy and satisfied about our cooperation" .*

8. Discussion

The purpose of the study was to examine the influence of the Technology Fair in developing undergraduate students' problem solving skills. The analysis of the results indicates that the Technology Fair has a significant influence on improving students' understanding and application of problem solving and decision making strategies within the area of Design and Technology.

From the analysis of the reflective diaries kept by university students, and their work (before and during the Fair) it can be concluded that the Technology Fair contributes to the development of positive values and attitudes in science and technology education. Furthermore, the Technology Fair fosters cooperation among the University of Cyprus and local schools. Important factors that emerge from previous research on the Science Fair and are confirmed by this study for the Technology Fair, is the enthusiasm and the motivation that this kind of education conveys to students [3] 1996, [5].

9. Conclusions

Based on the results of the tests, the reflective diaries and the interviews, it can be concluded that the technology fair can enhance the development of technological problem solving skills by pre-service teachers. Another important factor that emerged from this study is the enthusiasm and the motivation that this kind of education offers to both children and students. The technology fair seems to be considered by pre-service teachers as an important educational activity that will help them in their future career. From reflective diaries and interviews it can be concluded that the Technology Fair developed positive values for science and technology. In addition, during the fair, students expressed positive emotions both for the cooperation with children and for the learning gains.

Further research should include the design of teaching material to support the Technology Fair activities. The way students select their solution to the problem from a number of alternatives, through optimization, should be reconsidered (even though a significant improvement was achieved from pre-test to post-test) and a better design strategy should be considered in order to achieve better results. This study also identified a number of limitations that could be improved in future designs of the Technology Fair.

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