RESEARCH ARTICLE

Design and Technology Fairs as mechanisms for familiarizing student teachers with problem-solving practices

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Abstract

One aspect of inquiry-oriented learning refers to engaging students in extended problem solving activities of relevance to their everyday lives. This paper presents an innovative way in which university education can help pre-service teachers become better problem-solvers and also develop the capacity to promote children's competence in problem solving through design activities. The "Technology Fair" is used as part of a pre-service teacher-preparation program with an emphasis on design and modeling activities. This innovation was evaluated through a series of implementations since the autumn of 2004. The purpose of the present 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 educational value and meanings attached to problem solving practices by pre-service teachers. Pre-tests, mid-tests and post-tests were administered to the pre-service teachers before, during, and after the preparation of the technology fair, respectively. A number of pre-service teachers were selected and interviewed after the completion of the technology fair. Data were also collected from reflective diaries kept by the pre-service teachers during the preparation phase of the technology fair. Analysis of the results indicates that the technology fair contributes to the development of positive values and attitudes in Design and Technology education and has a significant influence on improving pre-service teachers' understandings of and competence with problem solving strategies within the domain of Design and Technology.

Introduction

The Technology Fair is an educational innovation derived from one interpretation of science fair projects as designed by the Learning in Science Group at the University of Cyprus and now implemented nationally throughout the educational system of Cyprus (Constantinou et al., 2004). Science fair projects have long been used as a mechanism for promoting scientific method skills with an emphasis on learning through empirical investigations. Identifying problems, formulating questions, making observations, proposing solutions, and interpreting data are important skills for students in school and throughout their lives. The core underlying idea has been to promote a type of education that places emphasis on these competences through science investigation activities, while simultaneously enhancing understanding of fundamental principles in science (Czerniak & Lumpe, 1997; Duggan & Gott, 1995).

The Technology fair was elaborated from the general idea of the science fair, which promotes learning by doing. It has been designed to promote problem solving as a key competence and an established practice of scientific inquiry. The main focus of the Technology Fair is on engaging students in the process of design through hands-on activities as an approach to developing methodical solutions to technological problems. Our interest in this area arose from the idea that participation in a technology fair could stimulate students' interest in Design and Technology education while simultaneously promoting the development of technological problem solving skills.

Theoretical Background

The approach to learning that includes consciously working towards a solution to a problem is often called 'Problem Based Learning'. It is an instructional approach that has already been implemented, at least on a trial basis, in elementary and secondary education (Delisle, 1997). It is also a core priority in inquiry oriented teaching and learning, especially when it refers to tasks that students can identify some personal relevance to (Hmelo-Silver et al., 2007). Problem-based learning typically begins with a problem for students to solve or learn more about. The problem acts as the stimulus and focus for student activity and learning (Boud & Feletti, 1991). 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.

Problems are designed to be 'ill-structured' and to imitate the complexity of real life situations. Often, they are framed around a scenario or case study format. Problem based learning assignments vary widely in scope and sophistication. Our approach uses an inquiry model: students are presented with a problem and they begin by organizing any previous knowledge on the subject, posing any additional questions, and identifying areas on which they need more information (Delisle, 1997). Students devise a plan for gathering more information, then do the necessary research and reconvene to share and summarize their new knowledge (Stepian & Gallagher, 1993).

Most of the technological problems that students are dealing with in Design and Technology education are ill-defined. Greenwald (2000) characterized an ill-defined problem as being: 'unclear and raises questions about what is known, what needs to be known, and how the answer can be found. Because the problem is unclear, there are many ways to solve it, and the solutions are influ¬enced by one's vantage point and experience' (p. 28). An ill-defined problem can be introduced to students within the context of a larger, realistic scenario. In design and technology education, ill-defined problems become better defined and more contextualized as they are worked on and hence the solving and learning is through doing.

In some approaches to Design and Technology education problem solving is conceptualized through a dynamic sequence of steps called the design process. In Cyprus, the national curriculum operationalizes this process as a sequence of eight steps:

1. Identify a need or a problem
2. Formulate the design brief
3. Write the specifications and limitations that the solution should satisfy
4. Search any relevant information
5. Draw/Sketch possible ideas/solutions for the problem
6. Select the best possible solution
7. Construct a prototype
8. Test and Evaluate the solution (redesign if necessary)

These steps can be implemented one after the other but can also be repeated as individual steps or combinations of them at any stage of the process.

The use of design as a means to technological problem solving is the dominant paradigm in technology education in many countries. Additionally, some researchers argue that the application of a design process makes it possible to guide students with little experience in tackling technological problems (Walker, 2000; Moriyama, 2002). This study is based on the teaching of a design process as part of a pre-service primary education programme. In our programme, we use the design process with non specialist pre-service teachers in order to provide a sense of security, a scaffolding framework and some guidance on how to approach technological problem solving. We explicitly avoid implementing the process as a serial sequence of steps and we also integrate into our teaching reflective mechanisms with a view to promote awareness of the different aspects of the design process and their complex inter-relationships.

To develop technological problem solving skills, students must merge design as a problem solving approach with the content of technology and integrate technical skills with problem solving skills. In our context, we have developed the technology fair as an activity that provides opportunities for our students (pre-service teachers) to work with children in order to gain practice in achieving this type of synthesis.

Very often technological problem solving can be very effective if promoted through hands-on, minds-on activities. Hands-on activities are materials-centered activities, manipulative activities, and practical activities (Doran, 1990; Hein, 1987). Elementary school science and technology teachers have long been interested in the use of manipulatives to provide concrete learning experiences (Ross & Kurtz, 1993).

Piaget stressed the importance of learning by doing, especially in science and technology. According to Piaget, 'a sufficient experimental training was believed to have been provided as long as the student had been introduced to the results of past experiments or had been allowed to watch demonstration experiments conducted by his teacher, as though it were possible to sit in rows on a wharf and learn to swim merely by watching grown-up swimmers in the water. It is true that this form of instruction by lecture and demonstration has often been supplemented by laboratory work by the students, but the repetition of past experiments is still a long way from being the best way of exciting the spirit of invention, and even of training students in the necessity for checking for verification' (Piaget, 1986, p. 705). Bruner also stressed learning by doing. 'The school boy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else' (Bruner, 1960, p. 14). Bruner states, 'Of only one thing I am convinced. I have never seen anybody improve in the art and technique of inquiry by any means other than engaging in inquiry' (Bruner, 1961, p. 31).

A hands-on, minds-on approach is also advanced by people who advocate a constructivist approach to science and technology education. 'Learning is defined as the construction of knowledge as sensory data are given meaning in terms of prior knowledge. Learning always is an interpretive process and always involves construction of knowledge.... Constructivism implies that students require opportunities to experience what they are to learn in a direct way and time to think and make sense of what they are learning. Laboratory activities are appealing as a way of allowing students to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science' (Tobin, 1990, pp. 404-405).

earning by design is a form of project-based learning in which students engage in just-in-time learning in an effort to develop a design for a solution to a problem or an aid to a human need. Design and Technology projects typically use engineering design processes as a foundational structure for scaffolding the work of students. This structure refines the design outcomes through processing of both ideas and data and provides an organizaton of the conceptual learning that underpins the analysis of the initial problem and the development of a product or a process as a prototypical solution. Additionally, modeling activities, in which students are challenged to deliver a design specification informed through research on prior approaches and a physical model of a solution, help to elicit student thinking and make it visible to the instructor and to themselves. This provides a more authentic approach to understanding the underlying principles and relationships, as well as to develop graphicacy and mathematics as thinking tools.

The Technology Fair

During the technology fair primary school children, with the assistance of pre-service teachers are responsible for identifying a human need, formulating a technological problem, collecting information and developing an appropriate solution. Each pre-service teacher was responsible for collaborating with one child (aged 10-12) on a single technological project.

In this context, technology fair projects provide an opportunity for interaction between pre-service teachers and primary school students so that they can work as a team with shared but different goals: the child aims to solve a technological problem and present both the description of the problem and its solution during the technology fair; the pre-service teacher aims to use the interaction as a process for helping the child develop technological problem-solving skills through a systematic approach (Mettas & Constantinou, 2005).

Once the work of pre-service teachers and pupils reaches a level where specific products are available, the school organizes a public event where each pupil displays a poster describing their designing (figure 1) and the constructed artifact (figure 2). In addition, pre-service teachers and pupils develop interactive activities specifically for the technology fair which are implemented with a view to engage the visitors in the learning process and enhance the educational value of the fair (figure 3).

This interactive activity should be of some relevance to the initial problem and their solution (Mettas & Constantinou, 2006). Through this activity they will attract interest and participation from the parent and student visitors to the fair. At this phase a whole day school event was organized, called the technology fair, and parents and other school children were invited to participate.

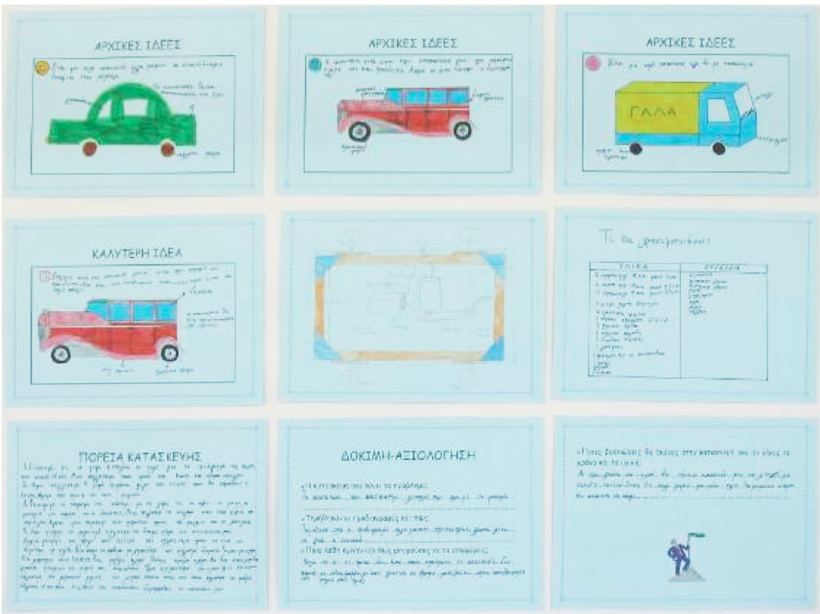

Figure 1: Typical poster presenting the design process in the technology fair

Figure 3: A model designed for a renewable energy house

Figure 2: Children interacting around a specially designed activity during the Technology Fair

During the fair, each pupil with his pre-service teacher displayed a poster describing the design process (see figure 1 for an example) Pupils and pre-service teachers also presented the artifact they constructed as a solution to the technological problem (figure 2).
Additionally, the children engage the public in a specific aspect of their work through a specially design interactive exhibit (see the photograph in figure 3).
Prior to the technology fair, the pre-service teachers received formal instruction for a period of 4 weeks on Design and Technology with particular emphasis on using design as a process of solving technological problems. During that period each pre-service teacher became engaged with a single technological problem and worked on developing and evaluating solutions to that problem as a member of a small group. They investigated the problem and designed a solution that satisfied explicit specifications to the extent possible. In the next phase, pre-service teachers prepared teaching materials and implemented them with primary education children as part of their technology fair preparation. A period of 4 weeks was needed for the preparation of teaching materials and the meetings with children. Figure 4 shows graphically the phases of the research and how the technology fair was implemented and assessed.

Purpose of the Research

The main purpose of the study was to investigate the effectiveness of the Technology Fair in developing pre-service teachers' problem solving skills and their pedagogical content knowledge about technological problem solving. More specifically, the purpose of the study was:

1. To examine whether the Technology Fair influences pre-service teachers' involvement and interests in Technology.
2. To improve our understanding of the processes used in developing technological problem solving strategies and how the technology fair could contribute in this direction.
3. To examine the understandings and strategies that the pre-service teachers develop in their effort to facilitate the development of technological problem solving by primary school children.

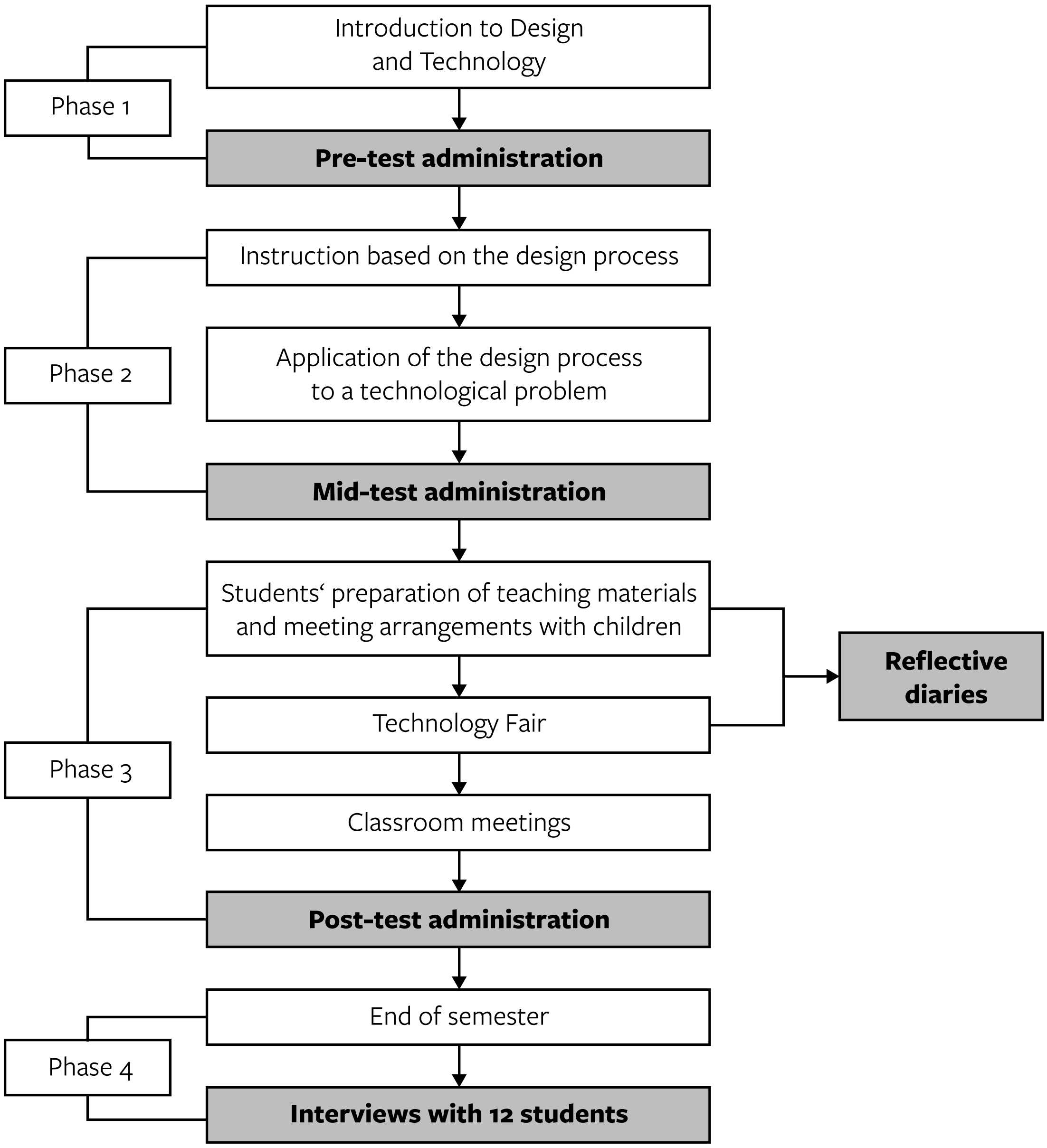

Figure 4: The technology fair course structure

Research Design, Methods and Sample

In order to assess pre-service teachers' understandings about the design process, a number of tasks were designed and organized into pre-tests, mid-tests and post-tests. Tests were administered to students before, during and after the preparation of the technology fair, respectively. Pre-tests, mid-tests and post-tests included exactly identical tasks. In addition, each pre-service teacher was asked to keep a detailed reflective diary after every meeting with the child. These diaries formed an additional source of complementary data. In the diary, each pre-service teacher recorded information about the 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 pupils. Finally, following the completion of the technology fair, 12 pre-service teachers were selected and interviewed about the experiences, problems and difficulties they faced as well as their interests and commitments while working with the child.

Sample

The sample of the research consisted of 82 pre-service teachers at the Department of Educational Sciences, University of Cyprus. All pre-service teachers were enrolled in a compulsory course in Design and Technology Education. The pre-service teachers were studying for the degree of primary education in order to serve as teachers. All students were in their second year of a four-year course and they were all coming from similar educational backgrounds, having graduated from the Cyprus state high school system. Consent forms were distributed to the whole class and the 82 pre-service teachers that took part in the study returned their completed form within one week.

Purpose of each Task in the Test

Six tasks were designed and organized into pre-tests, mid-tests and post-tests in order to assess the understanding of pre-service teachers in the application of design as a technological problem solving process. All the tests (pre-test, mid-test and post-test) consisted of identical tasks. The tasks were designed to assess specific aspects of design as well as design as a coherent process. The tasks were pilot-tested and improved for 2 semesters prior to this research study. The requirements for each task included in the test are shown below:

Task 1-Problem Identification: Requires pre-service teachers to identify a technological problem (or a need) from the domain of transportation. Specifically the actual task stated: 'Identify a need that could be considered as a technological problem, which you are able to solve, within the time limit and the available materials of the course on Design and Technology'.

Task 2-Design Brief: Requires pre-service teaches to formulate the design brief for the following technological problem: 'Many people travel from city A to city B every day. In-between the two cities there is a large lake that causes difficulties in their transportation, because people need to drive a long distance to reach the other side of the lake'. Therefore a new construction is needed that will be reliable, decrease the existing transportation time and secure easy access from one city to the other.

Task 3-Specifications: Requires pre-service teachers to identify the main specifications and limitations for a given product (Bridge model). For the requirements of that task pre-service teachers had to consider all the factors that could affect the design of a specific artifact, as shown in figure 2.

Task 4-Problem Investigation: Requires pre-service teachers 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 for the problem given to them in task 2. Pre-service teachers identified the most important factors and mentioned which information needed to be obtained in order to embark on developing the best possible solution.

Task 5- Alternative Solutions: Requires pre-service teachers to draw/sketch possible ideas/solutions for the problem given in task 2. The pre-service teachers were asked to draw a solution that is possible to be constructed by themselves within the course limitations (time limit and materials availability).

Task 6-Test and Evaluation: Requires pre-service teachers to test and evaluate a finished construction (bridge model). Pre-service teachers had to consider the product specifications that they mentioned in task 3 and then decide and describe the appropriate tests needed in order to evaluate the product.

Reflective Diaries and Interviews

Reflective diaries and interviews formed an additional source of data in relation to the pre-service teachers' strategies in applying the design process with the children. In the reflective diary, each pre-service teacher recorded a detailed description after every meeting with the child, as well as information about difficulties and problems they encountered while working with pupils and how they were able to overcome them. They described in detail every step of their design work. Additionally, teaching methods, emotions and ideas were reported after each meeting with the primary school pupil.

The purpose of the interviews with the pre-service teachers was to investigate their understanding of technological problem solving, their appreciation of its educational value and their approach to facilitating the development of relevant skills after their experience with the technology fair. The questions of the interviews were open ended and the pre-service teachers were encouraged to draw explicitly on their experiences while working on the technology fair. During the interviews, pre-service teachers initially responded to tasks of the same context as the tasks included in the test, eg. to identify a technological problem and formulate the design brief, to consider the main specifications of different products, to describe the kind of research and different information that could possibly inform the design and to evaluate some finished technological products.

Results

Responses to pre-tests, mid-tests, and post-tests were analysed using the phenomenographic approach developed by Marton (1981). Pre-service teachers' responses were organized into categories, which were then arranged hierarchically so that category 1 is the most appropriate category of responses, category 2 is cognitively less adequate than category 1 and better than category 3 etc. We undertook statistical analysis in order to examine the influence of the two parts of the teaching intervention ((a) formal teaching and own constructions, (b) preparing for the technology fair in collaboration with a child) on pre-service teachers understanding of the different aspects of technological problem solving.

The test consisted of 6 tasks that required understanding and implementation of different aspects of design in order to solve a new technological problem. The pre-service teachers' responses to four of the tasks (tasks 2, 3, 4, 6) were on an interval scale and, hence, were analysed using the paired samples t-test. The other two tasks (tasks 1, 5) had responses on an ordinal scale and were analysed using the (non-parametric) Wilcoxon Test.

Tables 1-3 show the results of the paired samples t-test for tasks 2, 3, 4 and 6. 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 by the pre-service teachers themselves. Table 2 shows the comparison between mid-test and post-test, i.e. the period during which the pre-service teachers guided a child to solve a technological problem and prepare for the technology fair, including the implementation of the fair itself. Table 3 shows the comparison between pre-test and post-test, i.e. the effect of the overall intervention (both parts) on pre-service teachers' problem solving skills.

Table 1: Paired samples t-test comparing Pre-test and Mid-test assessment data

Task	Mean Pre-Test	Mean Mid-Test	S.D. Pre-Test	S.D. Mid-Test	T	d.f	p
Task 2: Design Brief	1,13	1,56	1,08	0,92	-3,840	81	0,000
Task 3: Specifications	3,09	3,39	1,18	1,23	-1,783	81	0,078
Task 4: Information search	2,11	3,01	1,01	1,54	-5,185	81	0,000
Task 6: Test – Evaluation	1,21	1,39	0,94	0,78	-1,504	81	0,136

Table 2: Paired samples t-test comparing Mid-test and Post-test assessment data

Task	Mean Mid-Test	Mean Post-Test	S.D. Mid-Test	S.D. Post-Test	T	d.f	p
Task 2: Design Brief	1,56	2,51	0,918	0,633	-9,557	81	0,000
Task 3: Specifications	3,39	6,24	1,23	1,10	-17,518	81	0,000
Task 4: Information search	3,01	5,24	1,53	1,17	-12,191	81	0,000
Task 6: Test – Evaluation	1,39	2,54	0,78	0,70	-10,495	81	0,000

Table 3: Paired samples t-test comparing Pre-test and Post-test assessment data

Task	Mean Pre-Test	Mean Post-Test	S.D. Pre-Test	S.D. Post-Test	T	d.f	p
Task 2: Design Brief	1,13	2,51	1,08	0,633	-11,886	81	0,000
Task 3: Specifications	3,09	6,24	1,18	1,10	-18,304	81	0,000
Task 4: Information search	2,11	5,24	1,01	1,17	-19,503	81	0,000
Task 6: Test – Evaluation	1,21	2,54	0,94	0,70	-10,909	81	0,000

From table 1, we can see that pre-service teachers perform significantly better in mid-test as compared to the pre-test, in task 2 and task 4. The differences are statistically significant for both task 2 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 tasks 3 and 6. From tables 2 and 3, it can be seen that there are statistically significant differences for all the tasks, both from mid-test to post-test and from pre-test to post-test.

Tables 4-6 show the results of the Wilcoxon test for task 1 and task 5. Table 4 shows the comparison between pre-test and mid-test, table 5 shows the comparison between mid-test and post-test and table 6 shows the comparison between pre-test and post-test.

Table 4: Wilcoxon test comparing Pre-test and Mid-test performance on Tasks 1 and 5; (a) based on negative ranks; (b) Wilcoxon Signed Ranks Test

	Mid Task 1 – Pre Task 1	Mid Task 5 – Pre Task 5
Z	-1,605(a)	-1,043(a)
Asymp. Sig. (2-tailed)	0,109	0,297

Table 5: Wilcoxon test comparing Mid-test and Post-test performance on Tasks 1 and 5; (a) based on negative ranks; (b) Wilcoxon Signed Ranks Test

	Post Task 1 – Mid Task 1	Post Task 5– Mid Task 5
Z	-5,244(a)	-5,587(a)
Asymp. Sig. (2-tailed)	0,000	0,000

Table 6: Wilcoxon test comparing Pre-test and Post-test performance on Tasks 1 and 5; (a) based on negative ranks; (b) Wilcoxon Signed Ranks Test

	Post Task 1 – Pre Task 1	Post Task 5– Pre Task 5
Z	-6,140(a)	-6,277(a)
Asymp. Sig. (2-tailed)	0,000	0,000

From table 4, we can see that none of the differences between pre-test and mid-test are statistically significant for tasks 1 and 5. On the contrary, table 5 and table 6 indicate that there are statistically significant differences for tasks 1 and 5 from mid-test to post-test (Wilcoxon $Z = -5{,}244$, $p<0{,}01$ and Wilcoxon $Z = -5{,}587$, $p<0{,}01$, respectively) and from pre-test to post-test (Wilcoxon $Z = -6{,}140$, $p<0{,}01$ and Wilcoxon $Z = -6{,}277$, $p<0{,}01$, respectively).

Evidence from students' Reflective Diaries

Pre-service teachers' record in their reflective diaries were also analysed using a phenomenographic approach. A number of different factors in relation to technological problem solving emerge from the reflective diaries. The main findings are discussed below:

Almost every pre-service teacher (94%) characterized the opportunity to participate in the technology fair as a very important experience for their future teaching practice, eg. a pre-service teacher stated in her reflective diary: 'my cooperation with the primary school pupil was very important for my future studies. I found myself improving my teaching skills because of my interaction with the pupil'. Another pre-service teacher stated in his reflective diary: 'it was a very valuable experience, working with a primary education pupil. I tried different approaches with the child and I realized that these kinds of activities are important as part of our training as teachers'.

A significant number of pre-service teachers express their positive dispositions and values gained through the fair. They also consider themselves to be more effective in identifying technological problems and in a better position to overcome possible obstacles that they might encounter in the process of teaching technological problem solving, eg. a pre-service teacher stated in her reflective diary: 'I realized that simple technological problems could be drawn from every day activities, for example, where to store my toothbrush, how can I improve the appearance of my bedroom, etc'.

A large percentage (86%) of the pre-service teachers noted in their reflective diaries that primary school children worked through the design part of their projects with enthusiasm and positive attitude, eg. a pre-service teacher stated in her reflective diary: 'the pupil worked with enthusiasm during the design and construction of his project'. Another student said: 'the designing part of the project was great fun. Myself and the pupil were extremely motivated in our collaboration by the idea of the participation in the technology fair'.

Evidence from students' interviews

During the interviews, pre-service teachers expressed their beliefs about their experiences from their participation in the technology fair. They also responded to tasks in relation to technological problem solving. The main outcomes from the interviews are presented below:

Pre-service teachers expressed the belief that after the technology fair they were more confident in teaching the subject of Design and Technology in primary school, eg. a pre-service teachers said during her 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'.

The overall process and the presentation of their work in the fair seem to enhance pre-service teachers and pupils' motivation and interest in the area of technology, eg. a pre-sevice teacher said during the 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'.

Discussion

The purpose of the study was to examine the influence of the technology fair in developing pre-service teachers' problem solving skills. The analysis of the results indicates that the technology fair has a significant influence in improving pre-service teachers' understanding and application of problem solving strategies within the area of design and technology education. The results from the tests, reflective diaries and interviews triangulate and offer substantial support to this conclusion.

From these results it emerges that the technology fair can be considered as an effective teaching approach. The comparison of pre-test and mid-test, ie, the period from the introduction to the subject of Design and Technology up to implementation of the design process in workshop, indicates that there are statistically significant differences only for two out of the six tasks. The two tasks that demonstrated statistically significant differences were related with the formulation of the design brief and the search for information that can contribute to a successful solution. These are influenced by theoretical strategies and hence the impact of formal instruction is understandable.

In contrast, there are statistically significant differences for all tasks for the comparison between the mid-test and post-test, i.e. the period before and after the technology fair for all tasks included in the tests. This outcome, in connection with the analysis of reflective diaries and interviews demonstrates that the pre-service teachers' engagement with the organization of the technology fair strongly influences their abilities to research and solve technological problems through processes of design. The effectiveness of problem based learning in education was also identified from other researchers as well (Boud & Feletti, 1991; Chard, 1992).

A possible explanation for this outcome is that the responsibility that was undertaken by pre-service teachers to work with a child and present their results in the technology fair, helped them to focus their efforts and work more effectively. Results obtained from previous research (Hoffman & Ritchie, 1997) show that students involved in problem-based learning are more likely to acquire knowledge and become proficient in problem solving and self-directed learning.

During the preparation of the technology fair, pre-service teachers worked harder and sought feedback on their work more frequently than during the formal instruction period in which traditional learning approaches were used (before the technology fair). Throughout the technology fair pre-service teachers indicated an interest both about the designing of a technological project, and for possible pedagogical approaches that could be usefully implemented within design and technology education. Project based learning has been shown to be effective in increasing pre-service teachers motivation and in improving their problem-solving skills. Analogous results have been reported by Blumenfeld et al. (1991) who consider project-based learning as an effective and stimulating teaching approach.

From the analysis of pre-service teachers' reflective diaries and interviews, it can be seen that the technology fair contributes to the development of positive values and attitudes in design and technology education. Many pre-service teachers express the belief that the atmosphere during the technology fair was very stimulating and technologically rich. Technologically rich environments were also considered by Riel (1994) to be a very important factor that fosters positive values and interest in technology education. Positive values and attitudes that are developed as a result of the technology fair will help pre-service teachers to enhance their interest in technology education in general and in technological problem solving in particular when they come to serve as a teachers.

Important factors that emerge from this study are the enthusiasm and the motivation that this kind of education conveys to pre-service teachers. This outcome is evident both from pre-service teachers' reflective diaries and interviews. Most of the children express the willingness to participate again in a technology fair, while many pre-service teachers stated that they will consider undertaking the organization of a technology fair in their future career as primary education teachers. Children's enthusiasm and motivation for this kind of education was also obvious from observations during the days of the technology fairs.

There are a plethora of benefits that pre-service teachers and primary school children adduce to hands-on learning as part of the technology fair. The evidence from the current study supports that hands-on activities through the technology fair increased learning outcomes, increased motivation to learn, increased enjoyment of learning, increased skill proficiency (including communication skills), increased independent thinking and decision making based on direct evidence and experiences; and increased perception and creativity.

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 approach to teacher education offers for both children and pre-service teachers.

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 to pre-service teachers towards technological design. In addition, during the fair, pre-service teachers expressed positive viewpoints both for their cooperation with children and for the educational value of the technology fair.

This study also identified a number of limitations that could be improved in future designs of the technology fair. Further research is needed in order to extent this study with the design and evaluation of teaching materials to support the technology fair activities. The research can also be extended to examine in depth how students address design problems spontaneously. Observations of students and children while working towards the technology fair can provide another source of valuable data in this effort.

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