The Development of Decision-Making Skills

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This paper suggests an innovative idea of using the "technology fair" as a means for promoting pre-service teachers (university students) decision-making 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 decision-making skills of undergraduate primary education students (pre-service teachers). Pre-tests, mid-tests and post-tests were administered to undergraduate students before, during and after the preparation of the technology fair, respectively. Data were also collected from reflective diaries kept by the university students during the preparation of the technology fair. A number of students were selected and interviewed after the completion of the technology fair. The analysis of the results indicates that the technology fair has an influence on improving university students' decision-making strategies within the domain of design and technology.

INTRODUCTION

In life, we continuously go though processes of decision-making or selection from available or created options. From a very young age people make various decisions daily. Decision making is at least in part about making trade-offs. Rarely are we given a perfect option, an alternative that perfectly satisfies or meets all the appropriate criteria. Typically, certain options meet some criteria better than others. How do we make decisions about the criteria? How do we decide we would rather give up some of this in order to have some of that? What educational teaching processes could improve pupils' decision making strategies?

Primary education university students (pre-service teachers), as part of their studies, worked with primary school children to identify and solve a technological problem, and present both their design work and their solution of the problem in a school event that we call "technology fair". This paper explores the potential role of the technology fair as a context for improving the decision-making skills of university students. The study focuses on a specific strategy for decision making, namely "optimization", which enables students to make decisions with multiple and conflicting objectives.

THEORETICAL BACKGROUND

Recent education policy documents have called for a closer link between *Design and Technology* teaching and the development of decision-making skills (AAAS, 1993; Fisher, 1990; Wehmeyer, 2002). Decision-making refers to the choice of the most appropriate solution among possible alternatives. Kortland (1996) points out that decisions are reasoned choices, built on criteria that are not formulated from the beginning, but developed in interaction with the evaluation of the choices available (Jimenez-Aleixandre and Pereiro-Munoz, 2002).

Many research papers that make reference to decision-making come from the area of cognitive development (Sternberg, 1996; Birnbaum, 1998; Baron, 2000) or operational research, economics and management (Bazerman, 2005; Gibson et. al., 1997). In the field of educational research, decision-making strategies have only recently gained significant attention, with most of the studies related to science education (Patronis et. al., 1999; Kennett & Stedwill, 1996; Kolstø,

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State of the literature

- Literature suggests that the development of decision-making skills should be important part of general education.
- Despite the importance of decision-making skills there are limited studies exploring this phenomenon in practice.
- Research studies use optimazation techniques during their decision-making process. Optimisation is an analytical framework that is commonly used in Engineering in order to identify the best solution among a number of alternative options.

Contribution of this paper to the literature

- From the analysis of the results it emerge that technology fair has an influence on improving students' understanding and application of decision-making optimisation strategies.
- A number of difficulties faced by university students and primary education pupils in relation to decision-making, during the designing of a technology project were identified.
- A number of critical issues need to be reexamined in order to obtain more clear ideas.

2001; Papadouris & Constantinou, 2005). In design and technology education, there exist only few studies concerning decision-making (Davies, 2004; Coles & Norman, 2005). Davies (2004) argues that children's design decisions have an important role in understanding the relationship between technology and society. Coles & Norman (2005) suggests that values have an important role in design decision making.

Design and Technology education provides opportunities for students to develop an awareness and understanding of the importance of making informed choices that contribute to the development of society. Such awareness enhances students' thinking and encourages a tendency to reflect more critically and to make informed decisions as designers, makers or citizens (Patronis et al., 1999; Kennett & Stedwill, 1996). At the same time, society will influence students' design decisions through the operative values, trends and interactions (Norman,1998). Therefore, this is a bidirectional process of mutual influence between technological design process and social norms. In this context, there is a need for research on how decision making can be nurtured as ability from an early age and what Design and Technology education can contribute in this direction

A vital characteristic of a design and technology teacher is to empower students to make their own rational decisions. Decisions are required almost at every step of designing; whether we are evaluating alternative solutions or we are selecting from the range of appropriate materials that are available to be used we have to make decisions quickly and effectively (Davies, 2004). It is important that students' decisions are taken with an awareness of the different factors that influence the outcome.

Davies (2004) points out that it is important that young people consciously try to be objective in making judgments about their own products and products made by others. Understanding these relationships between design, technology and society is a significant aspect of students' preparation for citizenship and of making decisions about the kind of world we currently have and the kind of world we want to have.

When students design solutions to technological problems we present them with choices. Such choices relate to the kinds of materials and processes to use, the kinds of artefact they produce, whether their proposed solution involves hazardous processes, or will have features that might be dangerous for the user of the product (Middleton, 2005). During the development of the solution, values are an inescapable, if not always an overt part of the learning activities.

Coles and Norman (2005) point out that values have an important influence on designing behaviour. Decisions could be affected by preferences, opinions, emotions, culture characteristics etc, and therefore technological activities can rarely be entirely free of value judgement.

Technological decisions are not always straightforward. Prime (1993) argues, that technology "often poses real ethical dilemmas in which there are no obvious right answers or altogether satisfactory solutions. In such cases the challenge is to weigh all relevant contextual factors and to be guided by the values deemed to be more important in that situation" (p. 32).

Kimbell et al. (1996) argue that in technology education programs, little attention has been given to the discursive practices of justifying trade-offs, arguing for selection among alternative acceptable solutions, or persuading collaborators to contribute to a specific line of work. We have been limited by suggestions that the language of technology is dominantly a "concrete one; of graphics, symbols and models" (p. 25). This paper illustrates how a multi-criteria decision-making strategy, namely optimization strategy, can be used to make decisions regarding the selection of an optimum solution to a technological problem.

The Use of Optimisation Strategy in Decision-Making

Our research aims to improve the understanding of the different decision-making processes used by

students when using an optimisation strategy. Optimisation is an analytical framework that is commonly used in Engineering in order to identify the best solution among a number of alternative options. In this paper, the term optimisation refers to the decision-making process that is logically expected to lead to an optimal result. Optimisation is an activity that aims at developing the best (i.e., optimal) solution to a problem. For optimisation to be meaningful there must be alternative solutions available at various steps of the design process and more than one feasible solution must exist, that does not violate the constraints of the situation (Birnbaum 1998; Garnham and Oakhill 1994; Bazerman, 2005).

Optimization strategies can be used as a reasoning strategy that students can follow in design and technology education as a method for selecting an optimal solution among a number of options taking multiple criteria into account. The criteria could take different weight values and, therefore, comparisons between different solutions can be made on each criterion separately. The evaluations of the different alternative solutions with respect to each criterion normally involve the use of a distinct scale. Hence each

alternative solution is evaluated with respect to various measurement scales, one for each criterion. In order to choose the optimum solution that takes into account all the criteria and their weight factor it is necessary to convert all these evaluations/measurements to unique scale. This procedure is also part of the optimization strategy.

Different researchers specify a number of steps which can be applied in order to decide on an optimum solution (Bazerman, 2005; Hammond, Keeney and Raiffa, 1999, Birnbaum 1998; Garnham and Oakhill 1994). A typical example of a decision-making process using an optimisation technique is shown below:

Step 1: Define the problem. Good observation skills, accurate judgment and sometimes innovation are required to identify and define the problem. Common mistakes that might occur at this step are: (a) defining the problem in terms of a proposed solution, (b) missing a bigger problem, or (c) diagnosing the problem in terms of its symptoms. Our goal should be to solve the problem, not just eliminate its temporary symptoms. At this step of the decision making process, the aim should be to formulate a problem in a way that represents a corresponding human need.

Table 1. Criterion Weighting

Criterion Weight:	*Very Important* ⑤ ④ ③ ② ① *Not Important*
Criterion	**Criterion Weight**
Functionality	5
Safety	4
Aesthetics	3
Ergonomic	2
Available Time	2

Table 2. Alternative Solutions and Criterion Weights

Solution Value:	*Absolutely Satisfied* 4 3 2 1 0 *Not Satisfied*				
Criterion Weight:	*Very Important* 5 4 3 2 1 *Not Important*				
Criterion	**Criterion Weight**	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**
Functionality	5	4	2	3	1
Safety	4	2	3	3	2
Aesthetics	3	3	3	4	3
Ergonomic	2	2	3	2	4
Available Time	2	2	4	2	2

Table 3. Selecting an optimal solution with weighted criteria

Criterion	Solution 1	Solution 2	Solution 3	Solution 4
Functionality	(4x5=) **20**	(2x5=) **10**	(3x5=) **15**	(1x5=) **5**
Safety	(4x2=) **8**	(3x4=) **12**	(3x4=) **12**	(2x4=) **8**
Aesthetics	(3x3=) **9**	(3x3=) **9**	(4x3=) **12**	(3x3=) **9**
Ergonomic	(2x2=) **4**	(3x2=) **6**	(2x2=) **4**	(4x2=) **8**
Available Time	(2x2=) **4**	(4x2=) **8**	(2x2=) **4**	(2x2=) **4**
Total Score	**45**	**45**	**47**	**34**

Step 2: Identify the criteria. Most decisions require the decision maker to accomplish more than one objective. The rational decision maker will identify all relevant criteria in the decision-making process. Typical criteria that should be satisfied by the outcome of a design process include the following: product functionality, product safety while in operation, aesthetic aspects, ergonomic aspects and the time limitations.

Step 3: Weight the criteria. Different criteria will be of varying importance to a decision maker. Rational decision makers will know the relative value they place on each of the criteria identified. As an example in table 1, the relative importance of functionality indicated with a 5, which is considered to be very important while the relative importance of aesthetics is scored with 3, which is less important than functionality, yet more important than time limitations which is scored with 2.

Step 4: Generate alternatives. The fourth step in the decision-making process requires identification of possible solutions. Alternative solutions that comply with the criteria set in step 3 are identified. For example, solutions 1 to 4 in table 2 are considered to be the alternative solutions to a given problem.

Step 5: Rate each alternative on each criterion. How well will each of the alternative solutions achieve each of the defined criteria? This step typically requires the decision maker to make measurements, determine approximate evaluations or to forecast future events. The decision maker will be able to carefully assess the potential consequences of selecting any of the alternative solutions on each of the identified criteria. This step requires the combination of steps 3 and 4. For example, solution 2 is rated with a value 2 on the criterion of functionality; the relative criterion weight for functionality is rated with a value of 5.

Step 6: Compute the optimal decision. Ideally, after all five steps have been completed, the process of computing the optimal decision consists of: (1) multiplying the ratings in step 5 by the weight of each criterion, (2) adding up the weighted ratings across all of criteria for each alternative, and (3) choosing the solution with the highest sum of the weighted ratings. Table 3 shows the new values obtained after calculations of the weighted ratings.

For example, the score for solution 1 on the functionality criterion is 4 and this number should be multiplied with the corresponding criterion weight, which is 5 in order to obtain the normalized score of (4x5=) 20 (see table 3). The sum of all the normalized scores gives the total evaluation score for that solution. From Table 3, solution 3 has the higher score and seems to be the optimum solution. Therefore, it is the one that should be chosen to be developed.

METHODOLOGY

The Technology Fair

Our study is based on the organization and the implementation of a technology fair. In our context the technology fair is an educational innovation that was developed by the learning in science group at the University of Cyprus as a context for partnerships between universities and local elementary schools (Mettas & Constantinou, 2006; Mettas and Constantinou, (in press)). During the technology fair university students (pre-service teachers) are expected to prepare teaching materials, and collaborate with a primary education pupil each on a single technological problem such as, the need to reduce the consumption of fossil fuels in a home.

Pupils are guided by the pre-service teachers to identify a technological problem and then collect information on possible solutions to that problem. They subsequently analyze the context in which they identified the problem, in order to create detailed specifications, and as a result they develop a physical working model to meet explicitly declared specifications to the extent possible. During the preparation phase for the technology fair, each university student works with one pupil offering guidance and support for the child's design. Following each student-pupil pair develops their model solution and a poster describing their design process in detail. In addition, they prepare an interactive activity, some form of a game related to their topic.

University students and pupils worked together as a team for approximately a period of four weeks. Once the work of pupils reaches a stage where specific products are available, the school organizes a public event called the "Technology Fair" (Mettas and Constantinou, 2006). On the day of the technology fair the whole school along with the parents and visitors get together. Each child has a poster, their model solution and their game/interactive activity which is designed to engage visitors in a process of learning through interaction and manipulation of an artifact (Mettas & Constantinou, 2006). Throughout this process university staff offers feedback, guidance, resources and support to the university students.

In the context of university students and pupils collaborating on design project, there are various decisions that need to be made about their design and their construction work in order to end up with an optimum solution. A sample of decisions that had to be made during preparation for the technology fair includes:

deciding about appropriate materials for the design of the solution;
choosing the "best" solution among a number of alternatives;
deciding upon the appropriate type of mechanism or electrical circuit that should be used (how the outcome will function).

Purpose of the research and research questions

The aim of the study is to explore the ability of university students (pre-service teachers) to use optimisation strategies in order to make their choices, while engaging with the teaching of primary school pupils for the organization of the technology fair. Specifically, the research questions of this study are as follows:

I. How often do students apply taught optimisation strategies in their own design projects?
II. What are the difficulties that students encounter in their efforts to make decisions in the context of technological design?

III. What is the influence of the technology fair on students' decision-making through the use of optimisation strategies?

Data Collection

The study used both quantitative and qualitative research methods in order to collect and analyze data in relation to optimisation decision-making strategies. A single task was designed and given to university students in the form of pre-test, mid-test, and post-test. The task was based on the optimization strategy as presented in an earlier section. The task was administered to students at the beginning of the subject (before any formal teaching), after the formal teaching and before the technology fair, and after the technology fair respectively (25/10/2004, 8/11/2004 and 29/11/2004).

In addition to the decision-making task, each university student was asked to keep a detailed reflective diary after every meeting with the child. In the diary, each pre-service teacher recorded ee diary each student
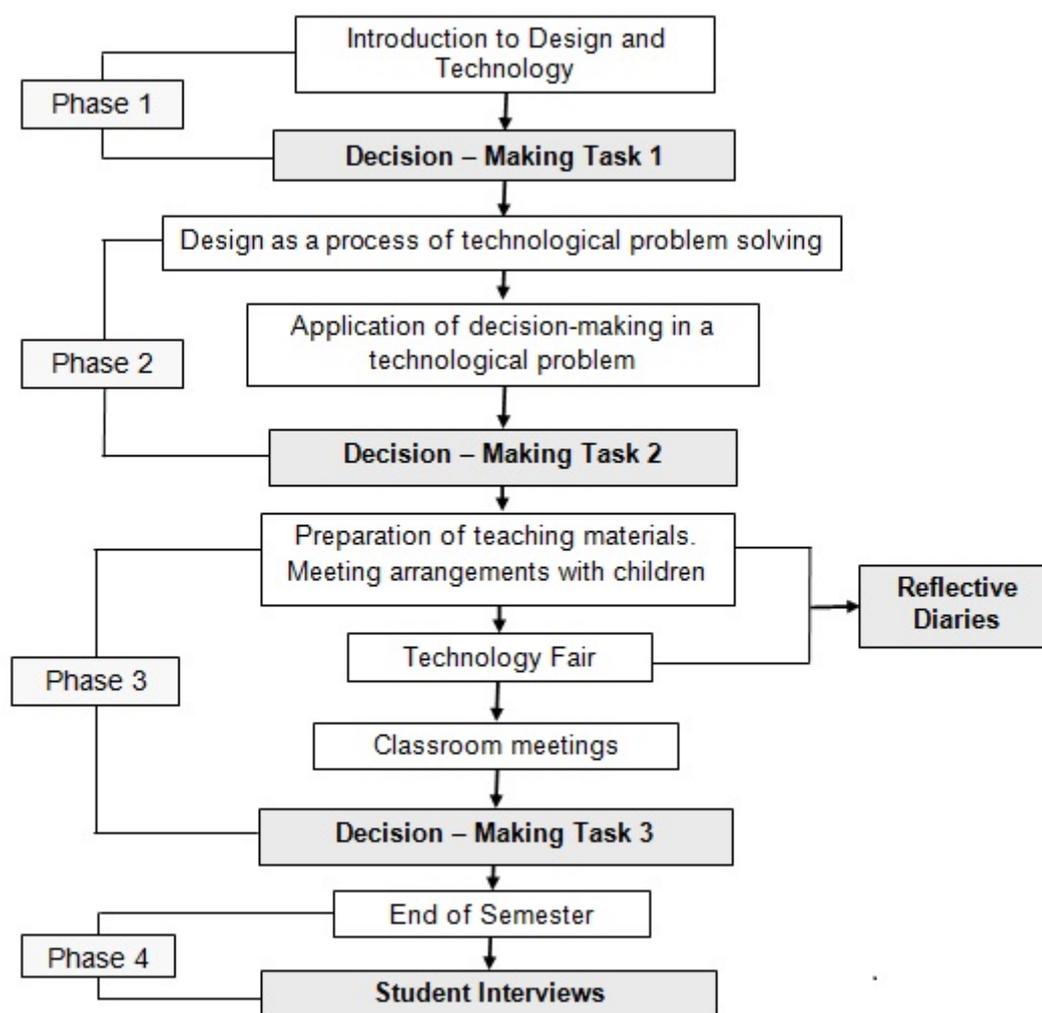

Figure 1. The research design

teachet recorded ata. ine p a detailed reflective diary after every meeting with the child. These all the information about their design decisions made while working for their project. The diaries were completed after each meeting with the primary school students. After the completion of the technology fair, 12 university students were selected and interviewed about their decision-making strategies while working for the preparation of the fair. Figure 1 shows the phases of the research and the data collection methods used.

Sample

The technology fair was held with the cooperation of a local primary school in November 2004. The sample of the research consists of 82 pre-service teachers studying for a degree in Primary Education at the Department of Educational Sciences, University of Cyprus. All pre-service teachers were enrolled in a compulsory course on Design and Technology Education.

Decision-Making Task in the form of Pre-test, Mid-test and Post-test

The task given to university students requires from them to choose the optimum solution using the optimization strategy discussed earlier. The actual task as given to students is presented in Table 4. The same task was given to them in all phases of the research (pre-test, mid-test, post-test). From table 4 it can be observe that all solutions were evaluated according to the most important criterions/specifications of the product. Some criterions/specifications have different weights between them and therefore have different importance. Students required deciding for the best possible solution using the information given in table 4, and also explaining their thinking strategies used while deciding.

Reflective Diaries and Interviews

Reflective diaries and interviews formed an additional source of data in relation to the use of optimisation decision-making strategies. In the reflective

diary each student recorded information about decision-making difficulties they encountered while working with pupil. The purpose of reflective diaries was to collect information about students' understanding of decision-making strategies used, while collaborating with elementary school pupils in designing a solution to a simple technological problem.

The purpose of the interviews was to investigate university students understanding of the decision-making techniques after their experience with the technology fair. The interview questions were open ended and based on university students design decisions made for their technology fair projects.

Research limitations and Weaknesses

The main weakness of the research is that the tests (pre-test, mid-test and post-test) were based only on a single task with an emphasis to optimisation strategies. As a result, it is difficult to envisage a valid measurement of such a complex area, like decision-making skills, from only a single task.

However, the results of the test gave interesting information of the use of optimisation strategies within design and technology activities. The data collected from students reflective diaries and interviews strengthen the reliability of the study. The results of the study will be considered for further research in the domain of technological design teaching.

ANALYSIS OF THE RESULTS

Phenomenographic Analysis

Students had to decide, which of the alternative solutions presented in table 4, is considered to be the optimum using an optimisation strategy. Responses to the task during the different phases of the research were analysed using the phenomenographic approach developed by Marton (1981). According to phenomenography, the responses are grouped into categories that fulfil criteria set in advance. Students' responses were categorized from two researchers in

Table 4. Selection of the optimum solution

Decision-making Task				
Please choose one of the solutions given to the Table using the information below. Explain the reasons of your decision.				
Solution Value: *Absolutely Satisfied* 4 3 2 1 0 *Not Satisfied*				
Criterion Weight: *Very Important* 5 4 3 2 1 *Not Important*				
Criterion	**Criterion Weight**	**Idea 1**	**Idea 2**	**Idea 3**	**Idea 4**
Functionality	5	4	3	2	0
Time Limit	2	2	2	4	4
Aesthetics	3	3	4	3	4
Ergonomic	2	2	2	3	4
Safety	4	2	3	3	4

order to increase the reliability of the study. The degree of agreement between the two researchers was 89%, which is considered to be satisfactory. The categories that emerge from the analysis were placed hierarchical, e.g. the category that is considered to be more suitable was placed first and then follows the next appropriate category. The categories identified from university students responses after the analysis are presented in order, from the optimum decision (category 1) to the worst decision (category 4). The following categories were identified from students' responses and were presented in hierarchical order. The percentages of frequencies for students responses for each category for pre-test, mid-test and post-test are presented graphically in Figure 2.

Category 1: Solution 2, their decision considered both the solution score and the criterion weight (optimisation)

Category 2: Solution 3, their decision considered only the solution score and not the criterion weight

Category 3: Solution 1, their decision was based only upon the best score in the most important criterion

Category 4: Solution 4, their decision does not take into account that one of the criteria is not satisfied

Processing the information given in table 4, the optimum solution for this task is consider to be the idea 2 (category 1), which is taking into account all criteria and their weight value (Optimisation). From figure 2 it can be observed that the number of students selected idea 2 increases from 42% in pre-test to 49% in mid-test and 77% in post test. The 27% of students in pre-test and 21% in mid-test selected idea 4, which is not taken into account that at least one of the criteria is not satisfied (functionality is scored with 0, which is not satisfied, category 4) and therefore this idea should be eliminated. Only 4% of pre-service teachers selected idea 4 to be the optimum solution in the post-test. The 13%, both in pre-test and mid-test and 11% in post-test, selected idea 3 (category 2), which is not taking into account the relative weight of the criteria and is taking into account only the values of each criterion separately. Students that selected idea 1 (category 3) considered only the most important criterion; idea 1 has the highest value in functionality, which is the most important criterion. The 18% in pre-test, 17% in mid-test and 9% in post-test selected idea 1 to be the best option for the task.

Statistical Analysis

The statistical analysis is performed using the non-parametric Wilcoxon test (table 5), because the data obtained from decision-making task given to students
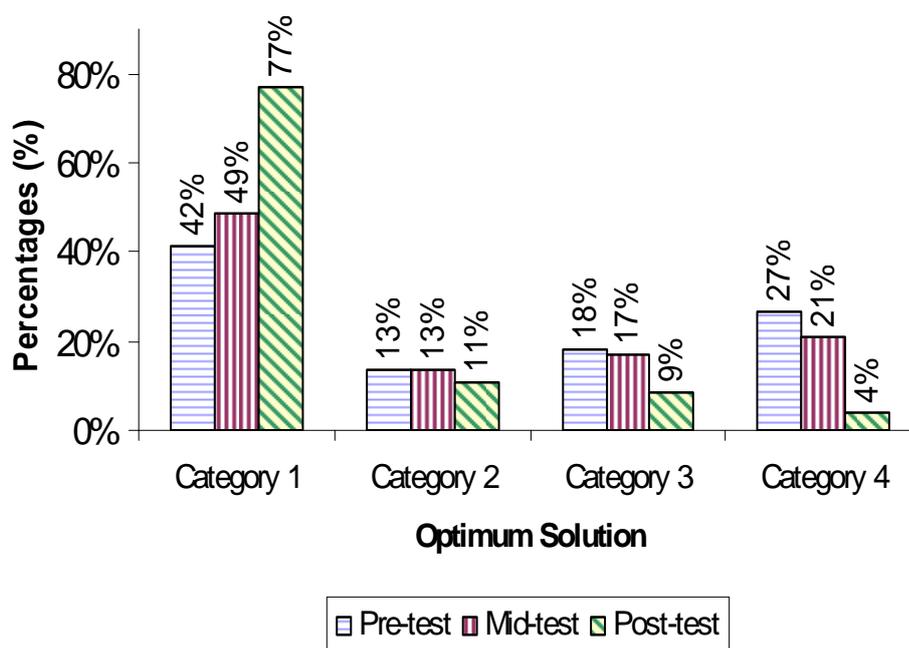

Figure 2. Students' responses percentages

Table 5. Wilcoxon test comparing Pre-test, Mid-test and Post-test

	Mid-test – Pre-test	Post-test – Mid-test	Post-test – Pre-test
Z	-1,502(a)	-4,310(a)	-4,978(a)
Sig. (2-tailed)	,133	,001	,001

a Based on negative ranks.   b Wilcoxon Signed Ranks Test

are on an ordinal scale. This statistical tool is appropriate for non-parametric data and compares the values of two tests in order to determine whether the differences between them are statistically significant or not.

Table 5 shows the results of the Wilcoxon test in pre-test, mid-test and post-test. From the comparison between pre-test and mid-test, i.e. the period from the introduction to the subject until the teaching and the implementation of the technological problem solving and decision-making process, it can be seen that the differences are not statistically significant ($Z(82) = -1,502$, $p > 0.01$). However, for the comparison between mid-test and post-test, i.e. the period from the preparation of the technology fair until the presentation of technology fair, there are statistically significant differences ($Z(82) = -4,31$, $p < 0.01$). Statistically significant differences can be observed between pre-test and post-test, as well ($Z(82) = -4,978$, $p < 0.01$), i.e. the period from the introduction to the subject up to the completion of the technology fair. These results confirm the impressions that emerge from looking at figure 2, the biggest changes in student performance on decision-making task were observed during the phase of preparation and accomplishment of the technology fair and not during formal instruction.

Indications from students' Reflective Diaries and Interviews

Students' reflective diaries and interviews were analyzed using the Phenomenographic approach (Marton, 1981). Students' responses were categorized and analyzed according to criteria set by the two researchers. The degree of agreement between the two researchers is 81% which is considered to be satisfactory. The main outcomes from the analysis are presented below.

Students express the belief that the technology fair gave them the opportunity to enhance their decision-making skills, e.g. a student said during his interview: *"the technology fair helped me to set more detailed criteria in relation to the product design. The weight of each criterion was also crucial to the final decision."* Some of the examples that students mentioned during the interview as assessment criteria were the product safety, environmental issues, product cost and materials availability.

Throughout the day that the technology fair was held, a significant number of different ideas were presented as a solution to various technological problems. Pre-service teachers expressed the belief, that it was interesting and helpful to see the optimisation concept used for different decisions made for various projects, e.g. a student said during his interview: *"during the designing part of our projects we tried to consider the best possible solutions. In the technology fair we saw that other people*

made different decisions for the same type of problem, which we didn't even think about. This part was very important in understanding the importance of values in design decisions".

In reflective diaries, a considerable number of students (86%) stated that the procedure of working with primary school pupils helped them to understand students' difficulties during the decision-making process, e.g. a student stated in his reflective diary: *"my cooperation with the primary school pupil was very important. I found that I had a better understanding of possible difficulties that pupils may face during their design decision-making".*

One of the main difficulties that university students faced while working with pupils was the weakness for both university students and pupils to identifying multiple assessment criteria in order to evaluate the possible solutions and choose the best among them. The majority of students could only mention attractiveness as the only criterion, e.g. a university student stated in his reflective diary: *"I realized that it's difficult to consider different criteria other than attractiveness. As a result there is a possibility to develop a solution that may not be the optimum".*

Some of the students (19%) did not follow any kind of optimisation technique as a strategy to make their decisions. They mentioned rules of thumbs or trial and error methods as an approach to make their decisions, e.g. a student mentioned during the interview: *"I found optimisation strategies difficult and time consuming as a technique for decision-making. I mainly made a number of trials in order to decide the appropriate materials or available shapes that are suitable in each case".*

DISCUSSION

The purpose of the study was to examine the influence of the technology fair in developing undergraduate students' decision-making skills using optimization technique. During the implementation of the technology fair, university students worked with primary education students for the designing and the construction of a solution to a technological problem. As part of that procedure a number of design decisions have been made from university students and children, as a team. This study identifies some of the strategies used from university students and children while working for the preparation of the technology fair.

From the results emerge that technology fair has a positive influence in improving students' understanding and application of optimization decision making skills. University students responses to the decision making task presents a slight improvement from pre-test to mid-test, i.e. the period from the introduction to design and technology and after the formal instruction about decision-making strategies. Despite the improvement of students results in using optimization strategies, the differences between the pre-test and mid-test are not

statistically significant (Z(82) = -1,502, P>0.01). In opposition, from the comparison between mid-test with post-test, i.e. the period before and after the technology fair, it can be seen that university students were able to use more effectively optimization strategies after the technology fair. The differences of mid-test and post-test were statistically significant using the non-parametric Wilcoxon test (Z(82) = -4,978, P<0.01). Statistically significant differences were obtained between mid and post test and between pre and post test: the technology fair was educationally more valuable than the formal part of the teaching intervention.

The analysis of the tests identified some difficulties that university students encounter when applying optimization techniques. Some students were unable to consider that the assessment criteria are not always of equal significance. As a result those students decided upon the best possible solution ignoring the criterions relative weights and therefore taking a decision assuming that all criteria are of equal importance. Another category of students took into account the criterion relative weight, but they based their decisions only considering the most important criterion and ignoring the significance of all the other criterions. Another group of students, showed difficulties to recognize that when an option does not meet a critical value in one of the criterion then the choice must be eliminated. Similar difficulties were identified from Papadouris et al. (2004) in a study with 12 years old children using optimization techniques in science controversial issues.

Those difficulties that identified through the analysis of the results are important to be consider when designing learning activities in design and technology education. The application of optimization strategies contributes to the enhancement of the ability to manipulate decisions with multiple and conflicting objectives. The application of such skills are important in everyday activities, because in many cases there are not perfect solutions available to us, and only with trade-off is possible to decide upon the most appropriate from those available. The developments of such skills are important in design and technology education, because many designing activities need to consider various alternatives and then decide for the best possible solution.

In addition to the results obtained from the pre-test, mid-test and post-test, reflective diaries and interviews form an alternative source of data. The results from reflective diaries and interviews support the argument that technology fair could improve students' development of decision-making skills. Many students reported in their reflective diaries that the organization of the technology fair helped them use more effectively optimization techniques.

From the results obtained from reflective diaries and interviews, some difficulties that students faced during design decisions making are acknowledged as well. Some students showed a number of difficulties when trying to evaluate alternative ideas. The main difficulty identified from the analysis of the data is the students' weakness to think appropriate criteria upon which they will assess possible alternative solutions. It was easy for students to set attractiveness as the main criterion for evaluation of alternatives, but hard to think of other evaluation criteria. Birnbaum (1998) argues that even adults often acquire difficulties to set suitable evaluation criteria in order to assess alternatives.

Another difficulty that emerges from the results is the complexity and the time required to use optimization strategies for a simple design decision. Students in some cases implement more simple strategies in order to make their decisions. Some of their approaches include trial and error methods or rule of thumps. An important issue that emerges from that outcome is the need to encourage students to identify situations where optimization technique could be valuable and worth the time needed, and situations where optimization will be time consuming and simpler techniques could be more appropriate. Clement (1991) argues that optimization and mathematical models are very important tools and they ensure that a decision will be rational. He goes on and argues that not every action deserves extensive thought and analysis before taking action. In fact, many of our day-to-day activities require us to make snap decisions. Part of becoming a good decision maker is being able to identify those situations that deserve careful thought.

Stanovich and West (2000) make a distinction between System 1 and System 2 cognitive functioning. System 1 thinking refers to our intuitive system, which is typically fast, automatic, effortless, implicit, and emotional. We make most decisions in life using System 1 thinking. By contrast, System 2 refers to reasoning that is slower, conscious, effortful, explicit, and logical (Kahneman, 2003). Bazzerman (2005) logical steps presented earlier forms a model of optimization technique and provide a prototype of System 2 thinking.

A number of decision-making techniques were used in order to guide the decision-making process. For he purpose of this paper the optimization technique was used in order to guide pre-service teachers' decisions. This method was used in other areas further than education like engineering and management. From the literature reviewed it can be concluded that students' decision-making processes are very complex and can be constrained from many factors.

Despite the importance of decision-making as a central and essential function in human behavior and the frequency of its use, there is little research aimed at teaching students in design and technology education

how to decide. This paper will contribute to the theory regarding the decision-making strategies in general and the use of optimization techniques in particular and difficulties that occur within the area of design and technology.

CONCLUSIONS

The purpose of the present study was to examine the influence of the technology fair in developing undergraduate students' decision-making skills through an optimisation strategy. The analysis of the results indicates that the technology fair has an influence on improving students' understanding and application of decision-making optimisation strategies within the area of design and technology.

The research identified some difficulties faced by university students and primary education pupils in relation to decision-making, during the designing of a technology project. The main difficulty identified from the study is the weakness of some students to consider a number of different assessment criteria in order to evaluate their alternative solutions. Those findings should be considered for a possible redesigning of the technology fair.

Although the results of the study indicates that the involvement of pre-service teachers with the technology fair, and their autonomous collaboration with primary education students is helpful to the enhancement of decision-making skills, a number of critical issues need to be reexamined in order to obtain more clear ideas. Therefore, more in-depth research is needed to examine the optimisation steps that pre-service teachers follow in the context of design-based problem solving activities.

Acknowledgement

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