Appendix A. Classification of the interactions between the children during the tasks: an example.

Number of the couple :……15.……

Gender of the children: ☐ males ☐ females ☐ mixed couple

Personality of the children: ☐ extroverts ☐ mediovert ☐ introvert

Interactions during the hypertext phase

Length of the task: ..1201 sec**…….**

Total length of interactions:….330 sec**…...**

Length of successful cooperative interactions……212 sec**……** **percentage ……**64,24 %**……**

Length of unsuccessful cooperative interactions……94 sec**……..** **percentage.....** 28,48%**.....**

Length of successful competitive interactions…….24 sec**……** **percentage**……7,27%**……..**

Length of unsuccessful competitive interactions……0 sec**……** **percentage**……0%**…….**

Description of the interaction	Length of the interaction (in seconds)	Type of the interaction
A child asking for information to the other child who answers	*15 seconds*	*Successful cooperative interaction*
A child asking for information to the other child who doesn't answer.	*11 seconds*	*Unsuccessful cooperative interaction*
A child tries to bring the mouse to the other child who resists.	*8 seconds*	*Successful competitive interaction*
The children speak together about the hypertext	*14 seconds*	*Successful cooperative interaction*
A child asking for information to the other children who answer	*21 seconds*	*Successful cooperative interaction*
A child tries to bring the mouse to the other child who resists	*5 seconds*	*Successful competitive interaction*
The children look at the hypertext, they are speaking about it	*16 seconds*	*Successful cooperative interaction*
A child asking for information to the other child who doesn't answer.	*21 seconds*	*Unsuccessful cooperative interaction*
A child tries to bring the mouse to the other child who resists.	*4 seconds*	*Successful competitive interaction*
The children speak together about the hypertext	*17 seconds*	*Successful cooperative interaction*
A child asking for information to the other children who answer	*19 seconds*	*Successful cooperative interaction*
A child asking for the mouse to the other child who gives it	*5 seconds*	*Successful cooperative interaction*
.....	.....	.....

Interactions during the questionnaire phase

Length of the task: ..1425 sec**…**

Total length of interactions:……524 sec**…….**

Length of successful cooperative interactions……358 sec**….** **percentage ……**68,32%**……**

Length of unsuccessful cooperative interactions……115 sec**....** **percentage**.....21,95%**.....**

Length of successful competitive interactions……51 sec**...** **percentage**……9,73%**……**

Length of unsuccessful competitive interactions……3 sec**….** **percentage**……...0,57%**.....**

A child takes the questionnaire so the other can't see it. The second child doesn't answer.	*5 seconds*	*Unsuccessful competitive interaction*
Children read together the questionnaire and answer to the questions	*14 seconds*	*Successful cooperative interaction*
A child asking for information to the other child who is loafing	*13 seconds*	*Unsuccessful cooperative interaction*
A child asking for the pen to the other child who gives it	*8 seconds*	*Successful cooperative interaction*
Children read together to the questions	*14 seconds*	*Successful cooperative interaction*
A child takes the questionnaire so the other can't see it. The second child doesn't answer.	*10 seconds*	*Unsuccessful competitive interaction*
A child asking for the pen to the other child who gives it	*12 seconds*	*Successful cooperative interaction*
Children read together the questionnaire and answer to the questions	*13 seconds*	*Successful cooperative interaction*
Children read together the questionnaire and answer to the questions	*18 seconds*	*Successful cooperative interaction*
.....	.....	.....

Interactions during the two tasks

Total length of the two tasks: ..2626 sec**…** **Total length of interactions:**…..... 854 sec**…….**

Length of successful cooperative interactions……570 sec**…** **percentage ……**66,74 %**……**

Length of unsuccessful cooperative interactions……..209 sec**...** **percentage**..... 24,47%**.....**

Length of successful competitive interactions……75 sec**….** **percentage**……8,78%**……**

Length of unsuccessful competitive interactions……3 sec**……** **percentage**……0,35%**……...**

Rating university faculty performance using analytic hierarchy process

GERASSIMOS KEKKERIS[1] VASILIOS HATZIFILIPPIDIS[2] CHRISTINA METAXAKI-KOSIONIDOU[3]

[1]Democritus University of Thrace, Department of Primary Education
68100, Alexandroupolis, Greece. Email: Kekkeris@eled.duth.gr
[2]Democritus University of Thrace, Department of Primary Education
68100, Alexandroupolis, Greece. Email: vhatzif@sch.gr
[3]Democritus University of Thrace, 68100, Alexandroupolis, Greece.
Email: metaxaki@otenet.gr

Abstract:

The purpose of this paper is to outline a framework which can be used to evaluate candidates for a faculty position. The methodology employed is based on the Analytic Hierarchy Process (Saaty,1982). This method permits the introduction of individual parameters to resolve the conflict that normally arises when incompatible criteria underlay the selection process. Because of the large number of factors involved in the model, the overall problem is decomposed into three sub-problems individually focusing on research results, educational ability and social contribution respectively. The results from each are then combined to yield the final ranking. To demonstrate the methodology, an example is developed based on the ranking of three candidates with different achievements. Computational results are presented along with their implications.

INTRODUCTION

One of the most important issues facing organisations like universities is the identification and selection of candinates who will be used as teaching and research staff. Attracting highly qualified staff has become an important issue (Flynn 1994; Chambers et al., 1998; Cappelli 2000). Private as well as public employers complain about the difficulties to select qualified employees (Gilot et al., 2002). One type of information, which has typically been used to make this selection, is the academic achievements of the applicants during their previous academic positions. A major problem with this information i.e. publications, educational ability, services to society etc. is that it can be measured variously, and that generally, applicants do not present a normal distribution of achievements in all that criteria which are usually characterized by a large number of interactive factors. Because of such limitations, in most cases, seems inadequate to make objective decisions and often decisions based on subjective knowledge or a complete logical resolution of the applicants if that ever is a possibility.

A review of the research literature indicates that has attracted limited attention to the staffing problem of universities. Although a number of studies have investigated the productivity (Cheng, 1984), administration (Newcomb, 1982), job performance (Dalessio, 1986), release time (Souder, 1981), barriers (Liker, 1986), and others (Davinson, 1983), (Pappas, 1985) no attempt have been made to measure academic qualifications.

A case study to test the feasibility of measuring output from university research has been carried out at Chalmers University of Technology (Wallmark, 1988) based on five factors: graduated degrees awarded, scientific publications, citations, patents and spin-off companies. These measurements have been subjectively combined and compared to inputs in the form of department budgets and other outputs such as the teaching load.

The method adopted here is based on defining the different research outputs and selecting a few of the most important factors which can be qualified. These outputs are then used to rank the qualifications of applicants for academic positions.

The methodology is based on the (Saaty, 1980), which utilises quantitative descriptions to define a problem and to represent the interactions of its parts. It also makes use of quantitative judgements to assess the strength of these interactions. The decision maker first identifies his or her main purpose in solving a problem. Criteria are chosen and weighted according to the priority of their importance to the decision maker. The different alternatives are then evaluated in terms of these criteria, and a best one or the best mix is chosen. The alternatives are then the potential solutions to the problem.

MATHEMATICAL BACKGROUND

Suppose that it is desirable to compare the total of n objects, at pairs, depending on their relative values. We name these objects A1,A2,…,An and w1,w2,…,wn their corresponding weights. We define the weight ratio as

$$w_{ij} = \frac{w_i}{w_j}$$

.We observe that the following relationships are true

$$w_{ij} = w_{ij}^{-1}, w_{ij} = w_{ik}.w_{kj} \text{ for all } i,j,k \qquad (1)$$

The following matrix W is defined as the matrix of weight ratios

$$W = \begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{pmatrix} = \begin{pmatrix} 1 & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \cdots & \frac{w_2}{w_n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & 1 \end{pmatrix} \quad (2)$$

The matrix W is called consistent, if the relations (1) are valid.

For the matrix W we observe that:

Since every row of W is a multiple of the first row, the rank of W is one, and thus there is only one non-zero eigenvalue which is n.

We can easily check that

$$W.w = n\,w \quad (3)$$

Therefore w must be the eigenvector of W corresponding to the maximum eigenvalue n.

As a living system, human perception and judgment are subject to change when the information inputs or psychological states of the decision maker change. A fixed weight vector is difficult to find.

Saaty [11] proposed the following to overcome this difficulty:

Estimate or elicit the weight ratio w_{ij} by a_{ij}. Let $A = (a_{ij})_{nXn}$ be the matrix of components $\{a_{ij}\}$. When n factors are being compared, n(n-1)/2 questions are necessary to fill the matrix, since $a_{ij} = \frac{1}{a_{ji}}$. Comparing objective i and objective j (where i is assumed to be at least as important as j), provide a value a_{ij} as follows (table 1):

Since A is found as an approximation of W, when the consistency conditions (1) are almost satisfied for A, one would expect that the normalized eigenvector corresponding to the maximum eigenvalue λ_{max} of A, will also be close to w. We have to solve the equation

$$A.w = \lambda_{max}.w \quad (4)$$

where w is the eigenvector corresponding to the maximum eigenvalue of comparison matrix A. The n elements of w are normalized (their sum is equal to 1). Consistency of response or transitivity of preference is checked by ascertaining whether

$$a_{ij} = a_{ik}.a_{kj}, \text{ for all } i, j, k. \quad (5)$$

Therefore, as an approximation, the elements of A can be thought to satisfy the relationship

$$a_{ij} = \frac{w_i}{w_j} + e_{ij}, \qquad (6)$$

where eij is the error term representing the decision maker's inconsistency in judgement when comparing factor i to factor j.

We can use the following approximation iterate method instead of solution of equation (6) .

- Take successive squared powers of matrix ?
- Normalize the row sums
- Go to step 1, until difference between successive row sums is less than a pre-specified value

Value	Definition	Explanation
1	Equal importance	Both factors contribute equally to the objective or criterion
3	Weak importance one over another	Experience and judgement slightly favour one factor over another
5	Essential or strong importance	Experience and judgement strongly favour one factor over another
7	Very strong or demonstrated importance	A factor is favoured very strongly over another, its dominance being demonstrated in practice
9	Absolute importance	The evidence favouring one factor over another is unquestionable
2, 4, 6,8	Intermediate values	Used when a compromise is needed
0	No relationship	The factor does not contribute to the objective

Table1: Scale used for pair wise comparisons

METHODOLOGY

In order to establish a general procedure for rating faculty performance alternatives, a set of well defined, uniformly acceptable criteria must be developed. This will be done in hierarchical framework.

The example developed below will be concerned with selecting a candidate for university faculty position. At the next level, the major considerations are defined, which in our case, will include research performance, education ability and services to society. This is usually followed by a listing the criteria for each of the above considerations.

With respect to research results, these will include research publications, industrial projects, patents, prototypes, cooperation (projects), etc. For educational performance these will include textbooks publication, doctoral dissertations, and development of new courses. For services to society these will concern consulting, advising based on previously acquired scientific and technical expertise and participation in working groups, committees, etc.

Depending upon how much detail is called for in the model, each criterion may then be broken down into individual parameters, whose values are estimated. The bottom lower level of the hierarchy contains the candidates who are involved in the problem.

In order to analyse the Figure 1, all the conections of candidates that are in level immedeately superior to the last one have not been drawn. For example, the elements "Consulting Advising" and "Popular literature" even though they are not analysed into inferior levels, of course they are connected to the last level of candidates. Simply there is not visible a shown connection in the figure.

CALCULATING THE WEIGHTS

The process of calculation the weights of criteria is based in the process described in fig 1. We concider the separate groups of criteria and for every one of them we take a table of comparisons and calculate the weights.

That is all, the tables of comparison at each level (except the first) and the correspondent priorities are calculated, and only then the process continues to the next level.

Second level

The first table at level 2, with elements A: "Research", B: "Education",

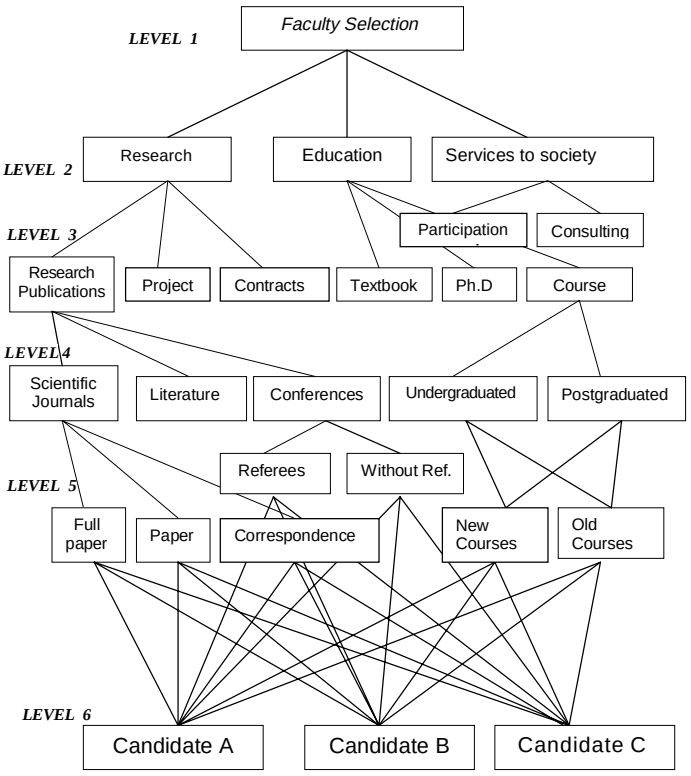

Fig. 1: The process of calculation

B: "Service to Society" is as follows (table 2):

	A	B	C	WEIGHTS
A	1	1	5	0.4545
B	1	1	5	0.4545
C	1/5	1/5	1	0.0909

Table 2: Level 2, with elements A: "Research", B: "Education"

The right column of the table contains the weights that came from the table. These weights are the local priorities, which in this case coincide with the total priorities, because the wight of element "Faculty selection" is equal to 1.

Third Level

At level 3, three tables are constructed. The first table refers to child-elements of "Research", that is A: "Research Publications", B: "Research Projects",C: "Research Contracts", (table 3).

	A	B	C	WEIGHTS	TOTAL
A	1	2	3	0.5396	0.2452
B	1/2	1	2	0.2969	0.1349
C	1/3	1/2	1	0.1634	0.0742

Table 3: Level 3, A: "Research Publications", B: "Research Projects",C: "Research Contracts"

The right column of the above table contains the total priorities which come from the local priorities.

The second table of comparisons at level 3 refers to the elements A: "Textbooks", B: "Doctoral Dissertations",C: "Course Developments"

	A	B	C	WEIGHTS	TOTAL
A	1	3	1/3	0.2683	0.1219
B	1/3	1	4	0.1172	0.0532
C	3	1/4	1	0.6144	0.2792

Table 4: Level 3, A: "Textbooks", B: "Doctoral Dissertations",C: "Course Developments"

The second table of comparisons at level 3 includes the elements A: "International Participation", B: "Consulting advising"

	A	B	WEIGHTS	TOTAL
A	1	3	0.25	0.0227
B	1/3	1	0.75	0.0681

Table 5: Level 3 includes the elements A: "International Participation", B: "Consulting advising"

Forth Level

At level 4 we have two tables. The first table comes from "Research" element and refers to elements A: "Scientific Journals", B: "Popular literature",C: "Conferences", (table 6).

	A	B	C	WEIGHTS	TOTAL
A	1	5	3	0.6175	0.1514
B	1/5	1	1/5	0.0856	0.0209
C	1/3	5	1	0.2968	0.0728

Table 6: Level 4, the first table comes from "Research" element and refers to elements A: "Scientific Journals", B: "Popular literature",C: "Conferences"

The seconf group of criteria comes from analysis of Course development into Undergraduated (A) and Postgraduated (B) departments. The table of comparison is the following:

	A	B	WEIGHTS	TOTAL
A	1	1/2	0.333	0.0930
B	2	1	0.666	0.1861

Table 7: Level 4, Course development into Undergraduated (A) and Postgraduated (B)

Fifth Level

At this level we have 3 categories of criteria. The first comes from the analysis of scientific Journals into A: "Full paper", B: "Paper", and C: "Correspondance" (table 7).

	A	B	C	WEIGHTS	TOTAL
A	1	4	7	0.6955	0.1052
B	1/4	1	4	0.2290	0.0346
C	1/7	1/4	1	0.0754	0.0114

Table 7΄: A: "Full paper", B: "Paper", and C: "Correspondance"

Then, follows the analysis of Conference publications with referee processing and to those without referee processing and we have the following table of comparisons.

	A	B	WEIGHTS	TOTAL
A	1	5	0.8333	0.0606
B	1/5	1	0.1666	0.0121

Table 8: Conference publications with referee processing (A) and to those without referee processing (B)

Finally, we analyze the courses into New (A) that are developed by the candidate and Old (B). Two tables of comparison must be constructed. One for under graduated course (table 9) and one for Post graduated courses (table 10).

Undergraduated course

	A	B	WEIGHTS	TOTAL
A	1	1/2	0.333	0.031
B	2	1	0.667	0.062

Table 9:

	A	B	WEIGHTS	TOTAL
A	1	1/3	0.25	0.04652
B	3	1	0.75	0.1395

Therefore we have for the total weights of the courses
New course development 0,2015
Old course 0,07752

AN APPLICATION

In the previous section, the weights of criteria were calculated. These criteria which are connected with the choices, have the following overall weights (table 11):

Full paper in scientific Journals	0,1052
Paper in inscientific Journals	0,0346
Correspondence to scientific Journals	0,0114
Publications to Popular literature	0,0209
Conference Publications with referees	0,0606
Conference Publications without referees	0,0121
Research projects	0,1349
Research contracts	0,0742
Textbooks	0,1219
Doctoral dissertetions	0,0532
New course development	0,2015
Old course	0,0775
Service to society	0,0227
Consulting Advising	0,0681
Total sum	0,9988

Table 11: Overall weights

These criteria are connected with the choices. They are summarized with satisfactory precision 0,1% into the unit. In order to choose the right candidate, a table of comparison for each criterion is constructed, and the overall performance of each candidate will be the synthesis of his local performances in the various criteria.

Candidate	A	B	C
1. RESEARCH			
full paper publications in Scientific Journals	4	1	-
paper publications in Scientific Journals	5	4	7
correspondence publications in Scientific Journals	10	3	13
popular literature publications	-	-	√√√
conference publications in scientific conferences with referees	10	-	-
conference publications without referees	-	-	3
Long-standing research cooparation in institutes abroad	√√√	√	√
participation in european scientific cooparative programs	2	-	-
2. EDUCATION			
textbooks	-	2	4
doctoral dissertations	-	3	-
new course development	-	2	1
old courses	4	8	6
3. SERVICE TO SOCIETY			
relations with society	limitative	√√√	√
cooperation with industry	√	√√	-

Table 12: Comparison list of achievemts of the three candinates.

The process is given more clearly with an example. Suppose we have the curriculum vitae of three candidates for a position to the University with the following elements each (table 12).

By constructing the tables of comparison according the overall performance of each candinate (table 12), the total priorities are calculated (table 13).

Criterion 1	CANDIDATES		
	A	B	C
RESEARCH			
Full paper publications	0,0675	0,0325	0,0052
Paper publications	0,0079	0,0042	0,0224
Correspondance Journals	0,0037	0,0008	0,0067
Popular literature publications	0,0019	0,0019	0,0171
Conferences with referres	0,0496	0,0055	0,0055
Conferences without referres	0,0011	0,0011	0,0099
Research projects	0,0919	0,0064	0,0364
Research contracts	0,0505	0,0200	0,0035
Total	0,2741	0,0724	0,1067
Criterion 2	CANDIDATES		
	A	B	C
EDUCATION			
Textbooks	0,0064	0,0308	0,0845
Doctoral dissertations	0,0044	0,0375	0,0112
New course development	0,0118	0,1413	0,0483
Old course	0,0111	0,0442	0,0221
Total	0,0337	0,2538	0,1661
Criterion 3	CANDIDATES		
	A	B	C
SERVICE TO SOCIETY			
International participation	0,0025	0,0176	0,0025
Consulting advising	0,0446	0,0197	0,0037
Total	0,0471	0,0373	0,0062
FINAL PRIORITIES	A	B	C
	0,3549	0,3635	0,2790

Table 13: Table of comparison with the total prioritis of three candinates.

COMMENTS

Following the above analysis, we observe that candidate B came first, with very small difference from A. Candidate A is good in research, while B is better in his educational effort. The fact that B is weaker in research than A is in his educational work overcomes the light supremacy of A in social attendance and so B takes the advantage.

Candidate C has zero social attendance and despite of having balanced performances into two main criteria, he is distinguished from.nobody.

CONCLUSIONS

It has been shown how the Analytic Hierarchy Process can be used to evaluate the performance of candidates for University faculty positions. The methodology is general and can be modify to fullfill the needs of each department. In this case, the major considerations, criteria and parameters developed for each department should not be thought as fixed.

Other promising areas of application include the ranking of students for postgraduate studies, the selection of technology for large scale projects and the determination of strategic direction of the department. Each new problem will usually require modifications to accommodate unique concerns. The AHP method is enough flexible and easily permits such modifications.

The advantage of the approach used is that it combines qualitative and quantitative inputs and can be used effectively in the early stages of the selection when the curriculum vitae are aivalable.

BIBLIOGRAPHY

Cappelli, P. (2000). A market-driven approach to retaining talent. Harvard Business Review, 103-111.

Champers, E.G., Foulon, M., Handfield-Jones, E.G., Hankin S.M. & Michaels, E.G. (1998). The war for talent. McKinsey Quarterly, 44-57.

Cheng, J. L. C. (1984). Organizational staffing and productivity in basic and applied research: A comparative study. IEEE Trans. on Engineering Management, 31, 3-6.

Dalessio, A. (1986). Academic success and job performance of engineering and scientific personnel. IEEE Trans on EM, 33, 67-71.

Davinson Frame, J. (1983). Quantative indicators for evaluation of basic research programs/projects. IEEE Trans on EM, 30, 106-112.

Gilliot, D., Overlaet, B. & Verdin, P. (2002). Tertiary and Education

Management, 8,277-295.

Flynn, G. (1994). Attracting the right employees and keeping them. Personnel Journal 73, 44-48.

Langan, S.(2000). Finding the needle in the haystack: The challenge of recruiting and retaining sharp employees. Public Personnel Management 29, 461-463.

Liker, J.K., Hancock, W. M. (1986). Organizational systems barriers to engineering effectiveness. IEEE on EM, 33, 82-91.

Newcomb, R. W., DeClaris, N. (1982). Improving the maze of University administration in high technology education. IEEE Trans on EM, 29, 62-67.

Pappas, R.A., Remer, D. S. (1985). Measuring R&D productivity. Res. Manag, 28(3), 15-22.

Saaty, T. L. (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. New York: McGraw-Hill.

Saaty, T.L., Vargas, L. G. (1982). The Logic of Priorities. London: Kluwer Nijhoff Publishing.

Souder, W. E. (1981). Effects of release time on R&D outputs and scientist's gratification. IEEE Trans on EM,28, 8-12.

Westbrook, J.H. (1960). Identifying significant research. Science, 132, 1229-1234.

Wallmark, J.T., McQueen, D.H. & Sedic, K.G. (1988). Measurement of output from university research: A case study.

Prospective teachers' conceptual understanding of phenomena related to thermal physics and its evaluation

SARANTOS PSYCHARIS[1], CHARALAMBOS BABAROUTSIS[2]

[1] University of Aegean, Department of Pedagogy,
Greek Pedagogical Institute -Deputy Counselor for Evaluation, psycharis@Rhodes.Aegean.gr
[2] Greek Pedagogical Institute -Deputy Counselor for Evaluation, hbab@pi-schools.gr

Abstract

In this work we present a questionnaire that has been given to prospective teachers in the Department of Primary Education of the University of the Aegean and represents an attempt to examine prospective teachers' views on concepts related to thermal phenomena as well as to improve students' understanding of these concepts. The students' answers have been classified according to the orientation of studies selected in order to be admitted to the Pedagogic Department and the results are presented here. The results reveal that perspective teachers share a number of misconceptions about thermal phenomena while the fewest misconceptions are present among the ones come from the scientific orientation.

Key words: evaluation, physics, heat, prospective teachers's conceptions.

INTRODUCTION

In recent years there is a growing research activity regarding the factors that affect the teaching of physics in prospective teachers for primary school. Some factors results from the education research, the incorporation of information and communication technologies in the education process, the physics content knowledge etc. (THACKER, 2003). This implies a focus on conceptual understanding and the cognitive skills required to understand and apply physics concepts, interactive methods for teaching and learning, change in science curricula and the incorporation of teaching methodologies into the Physical Sciences curriculum of the pedagogical departments (KOKKOTAS, *et al*., 1998).

Consequently, teaching and learning in Sciences must not be restricted only in accumulation of knowledge on concepts, but it must to extend on the developing of scientific skills that are related to the application of knowledge, development of scientific thinking and skills on problem solving. (HATZIKRANIOTIS *et al*., 1999; WOOLNOUGH, 1989).

On the other hand, research has shown that teachers with who have well developed subject matter cognitive structures are more efficient at presenting subject matter to students (NOTT & WELLINGTON, 1996; GESS-NEWSOME & LEDERMAN, 1995, VALANIDES (2000), SUMMERS (1992) & VALANIDES (2000)), the majority of primary student teachers hold views of science concepts that are not compatible with the scientific ones and obviously this influence children's understanding of science related concepts (NOTT & WELLINGTON, 1996; GESS-NEWSOME & LEDERMAN, 1995; JOHNSON, 1998) and teachers seem to hold "inadequate conceptions" of science (HODSON, 1993, PAPAGEORGIOY & SAKKA, 2000) or have ideas which are not scientifically accepted.

VALANIDES (2000) reports also that primary student teachers have limited understanding of the particulate nature of matter and the relation of observable macroscopic changes (i.e., change of phase) and it will affect their classroom behavior and teaching methods.

In this work we present the design and the implementation of a questionnaire constructed for the specific purposes of the present study and presented to prospective teachers of the Pedagogical Department of the Aegean University.

From the study it is evident that students misunderstand fundamental concepts related to thermal phenomena, some they are not familiar with the terminology of concepts related to thermal physics and some concepts are perceived in a limited way.

The study will extend next semester with the creation of a series of worksheets to accompany the questionnaire.

DESIGN OF THE STUDY

The purpose of the study was to investigate prospective primary school teachers' conceptual difficulties in understanding basic concepts and phenomena related to heat after they had received a course of instruction on heat energy. In the study we tried to focus on misconceptions about the difference of heat with temperature, the transfer of heat and the states of matter but we have remained on an elementary level. The study involved 33 of the Pedagogical Department of the University of the Aegean that come from the Scientific orientation (7), the Technological orientation (10) and the Theoretical orientation (16), and attend the subject "Children's Views on the Concepts of Physical Sciences". The students are in their first or second year of their studies and they are prospective teachers for primary school. The course is scheduled for three hours per week and lasts for twelve or thirteen weeks.

The course consists of mechanics, heat and optics. Students were informed that the information from the questionnaire was to be used for the design of the course and it is anonymous.

Prospective teachers have had experiences about teaching and learning in science concepts related to heat and thermal phenomena as students in secondary education.

All the prospective teachers had attended lessons on heat in lower secondary school while those that had selected the Scientific and Technological orientations had been taught a significant part of the heat engines and kinetic theory of gases in the second year of the upper secondary school.

The study was conducted after they had received both classroom and laboratory instruction on thermal physics for about two months (2 hours per week for classroom lecture and 1 hours per week for laboratory instruction).

The completion of the questionnaire lasted 60 minutes. Data from the questionnaire were classified according to the orientation they had selected in order to be admitted in the Pedagogic department. In the sample, 5 of the 33 students were men and 28 were women.