The Effects of a Preparatory Mathematics Program in Changing Prospective Teachers' Attitudes Towards Mathematics

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THE EFFECTS OF A PREPARATORY MATHEMATICS PROGRAM IN CHANGING PROSPECTIVE TEACHERS' ATTITUDES TOWARDS MATHEMATICS

ABSTRACT. In this study the results of a project aimed at changing prospective teachers' attitudes towards mathematics are reported. A mathematics preparatory program was designed and implemented over a period of three years. The program consisted of two mathematics content courses, based on the history of mathematics, and a methods course. A multidimensional questionnaire, supplemented at the final stage by interviews, was used to follow up the subjects' attitudes through the implementation period. The results indicated significant improvement of attitudes, particularly about the satisfaction from and the usefulness of mathematics.

THEORETICAL BACKGROUND

The significance of teachers' beliefs and conceptions as a factor in the process of teaching and learning is well established in the mathematics education literature (Lester, Garofalo and Croll, 1989; McLeod, 1994; Pehkonen, 1994; Thompson, 1992). Former research has substantiated the assumption that affective variables, such as conceptions, beliefs, and attitudes towards mathematics play a determinant role in the development of teaching practices. It seems, however, that only a limited number of studies have investigated preservice teachers' beliefs or attitudes, as opposed to numerous studies dealing with cognitive variables (Vale, 1993, cited in Fernandes, 1995). Moreover, only few pre-service programs have been investigated with respect to their effectiveness in affecting teachers' beliefs and practices (Fernandes, 1995). The present study aimed to provide longitudinal evidence concerning a program which was designed to improve the attitudes of prospective teachers towards mathematics.

The individual's conceptions and self-perceived relationship to mathematics are of primary importance in the formation of their learning and teaching behavior. This relationship is linked to beliefs about self-efficacy and was substantiated in numerous studies. For instance, Bandura (1986) considered self-efficacy beliefs as the strongest predictors of human motivation and behavior; these involve people's evaluations of their own competence to undertake particular tasks and 'beliefs about their capabilities

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to exercise control over events that affect their lives' (p. 1). Conceptions of self-efficacy result from complex processes of self-regulation and self-evaluation which take place during problem-solving. These then reflect back and affect the ability to control one's own and others' actions. That is, efficacy beliefs may enhance or undermine performance and influence selection of activities and environments; they are a key factor in the self-regulation of one's motivation to pursue a task or meet a challenge, such as the teaching of mathematics.

Efficacy beliefs are shaped by many factors. Among them one's history of perceived past successes and failures seems to play a major role (Smith, 1996). In order to be useful to researchers, efficacy beliefs need to be defined within the context of the specific behaviors under investigation. Thus, teachers efficacy beliefs are directly linked to and influence effort in the pursuit of goals, persistence in the face of adversity, and in general attempt to project control over their environment; they include aspects of 'self-confidence to affect students' performance and ... certainly confidence to perform specific tasks' (Pajares, 1992, p. 316).

TEACHERS' BELIEFS AND TEACHING BEHAVIOR

Beliefs may be defined as one's amalgamated mixture of subjective knowledge and feelings about a certain object or person. Beliefs are seen as distinct from knowledge; the latter must involve a certain degree of objectivity and validation vis-à-vis reality. Several researchers identify a nexus between teachers' beliefs in their abilities to teach, and student performance (Ashton and Webb, 1986; Chester and Beaudin, 1996). This relationship makes sense when one considers that the beliefs held by teachers influence their perceptions and judgments, which, in turn, determine their behavior in classroom. Teachers' beliefs in the form of predispositions and expectations of themselves and their students are important mediators of experiences and teaching behavior (Pajares, 1992).

Teachers' beliefs about mathematics and mathematics teaching play a significant role in shaping their instructional practice and consequently influence their pupils' attitudes, interests, and achievement (Thompson, 1992). Gibson and Dempo (1984) examined the relationship between teacher beliefs, academic focus, and teacher feedback behaviors. They found that teachers with high efficacy beliefs engage in practices that are associated with high achievement gains. High efficacy teachers conduct large-group and/or whole-class instruction, are able to keep other students engaged while instructing small groups, help low-achieving during failure situations, and praise rather than criticize students. In brief, 'the overriding goal' of high efficacy teachers is oriented towards enhancing mastery rather than increasing performance (Prawat and Anderson, 1994).

Summarizing the results of recent related studies, Fernandes (1995) concluded that: Teachers' formative experiences in mathematics emerge as key players in the process of teaching since what they do in the classroom reflects their own thoughts and beliefs. Most of the preservice programs do not seem to take into account the candidate teachers beliefs and attitudes towards mathematics. Studying teachers' thoughts, attitudes and beliefs provides information to be taken into account by teacher-educators in the process of improving teacher education programs. Therefore, questions concerning teachers' attitudes towards mathematics, such as 'How do these attitudes evolve' and 'How can they be altered' are of paramount importance to planners of programs for mathematics teachers. The scarcity of studies which examine the relationships between teacher characteristics, and efficacy beliefs indicates the need for more studies to enhance understanding of changes in the self-efficacy beliefs of prospective teachers, and to illuminate individual characteristics with respect to preparatory programs. Understanding the role played by these programs in enhancing or diminishing students' beliefs provides a foundation for re-examining teacher education programs.

EMERGENCE AND CHANGE OF ATTITUDES

A number of studies indicated that children normally begin schooling with rather positive attitudes towards mathematics; these attitudes, however, tend to become less positive as children grow up, and they frequently become negative at the high school (McLeod, 1992). The pressure exercised on children to cope with highly demanding tasks, frequently at a pace beyond their ambition, together with unimaginative instruction and non-positive teacher attitudes have destructive impact on their conceptions of mathematics. Mandler's 'discrepancy theory' (1989) interprets the emergence of negative attitudes as a result of frequent failures of planned actions, which were intended to face mathematical tasks. Repeated emotional reactions result in the formation of an overall schema about mathematics, which becomes a permanent source of beliefs and attitudes.

Prawn and Anderson (1994) found that 4th and 5th graders reported 'twice the amount of negative as compared to positive affect while engaged in mathematics seatwork' (p. 219). Hoyles (1982) found that 14 year old students tend to associate their mathematical experiences with feelings of anxiety, shame, and failure. Some of these students choose to become teachers and they eventually find themselves in the position to teach a subject they dislike. Unconsciously, these teachers influence negatively their students' attitudes and the system is moving into a vicious circle. The crucial question is when and how to break this circle down. Research in several cultural environments has shown that prospective teachers have rather negative attitudes towards mathematics (Ball, 1990; Philippou, 1994). It has been noticed that teacher education could make the difference (Fernandes, 1994) since during this period the student-teachers are exposed to long-lasting experiences organized under the leadership of experts in the field of mathematics education. It is, therefore, important for teacher-trainers to consider carefully and question the impact of their training programs.

Though the need to improve prospective teachers' attitudes was substantiated quite early, it was also realized that attitudes are not easily altered and that one should not expect noteworthy changes to come about over a short period of time. On the other hand, 'the wholesale replacement of beliefs is neither desirable nor likely to occur' (Smith, 1996 p. 395) since there is much value in past experiences. There is evidence that teachers' beliefs towards teaching can change during the course of university education and during early practicing, including the initial field experiences-practicum. Reys and Delon (1988) examined the effectiveness of a preparatory program at the university of Missouri: they used a Dutton scale prior and upon completion of single program courses and reported small changes in attitudes of preservice teachers towards arithmetic.

ATTITUDE CHANGE AND HISTORY OF MATHEMATICS

Despite an underlying desire to make better use of history in the teaching of mathematics, very few studies have examined the usefulness of history of mathematics in the classroom. History of mathematics is included among the programs of several universities in Europe but, to the best of our knowledge, there are very few reports on their effectiveness for teachers' preparation and particularly with respect to their beliefs. Stander (1991) found that the use of historical topics as enrichment materials made no difference in the attitudes of prospective primary teachers; though the majority of the subjects stated that they enjoyed reading about great mathematicians connected with mathematics they were studying, they were reluctant to spend time in searching about the historical development of mathematical concepts or ideas. This might have been due to the short duration of the experiment, and the treatment type since the enrichment material used was by no means an integral part of the mathematics course.

Schram et al. (1988) examined the effect of taught courses on prospective primary teachers' conceptions about mathematics. At the end of a 10-week course, positive changes were reported in the participants' conceptions about the nature of mathematics, the structure of mathematics classes, and the process of learning mathematics. Recently, Lindgren (1995) conducted a study on the belief system of prospective teachers and observed positive change in the structure of beliefs about teaching mathematics, after the completion of the first year of the program.

DESIGN AND PURPOSE OF THE PROJECT

A preparatory program was designed at the University of Cyprus with the aim to help prospective teachers make sense of and acquire mathematical concepts and methods in a comfortable environment, which would at the same time improve their self-confidence in doing mathematics. Care was taken to provide students opportunities for success experiences and help them reconsider their views about the nature of mathematics, the usefulness, and the difficulty of learning mathematics. Specifically, the program consisted of three courses: two mathematics content courses and one mathematics teaching course.

The design of the program was based on the assumptions that most of primary mathematics has its roots in the early historic period, and that preservice teachers would be motivated to read mathematics in the context of their initial development. It seemed plausible to expect Greek students to show a special interest in reading mathematics, mostly developed by their ancestors in their own language, under the conditions of their genesis. It was envisaged that following the evolutionary process of the subject would contribute not only to the understanding of mathematical concepts, but also to the development of a sense that mathematics is a constantly changing creation of human activity rather than a fixed and finished *a priori* existing product, which one is expected to discover. Hence, the content courses were designed to proceed along the historical-developmental lines (see Appendix).

A typical unit began by presenting the historical development of basic concepts and ideas with special emphasis on contextual factors, and proceeded to the present state of the art. For instance, through the struggle of Babylonians and Greeks to derive algorithms and perform operations in the sexagesimal and the alphabetical system, respectively, the students were given the chance to appreciate the conceptual meaning of the 'place value'. The aim of the discussion that followed was to understand and apply the properties of the place value to the decimal and other bases systems, and develop the algorithms of the four operations. During activity sessions, the students were involved in extensive discussions and tasks to acquire 'hands on' experience where both success and failure was expected by everyone. They spent much time on Euclid's fifth postulate and the laborious efforts through the centuries to 'prove it', as well as on the 'principle of exhaustion' proposed by Eudoxus, in relation to the present definition of the concept of limit. Working on a dozen of different proofs of the Pythagorean theorem, the students were expected to overcome the long cherished myth that each mathematical problem has always one single solution. Similarly, a study of the three famous problems of antiquity helped them realize that the solution of a problem depends on the 'rules of the game' and that failure is not necessarily futile. Finally, by allowing students to come through some of the successes and failures of great mathematicians familiarized them with thought provoking experiences with regard to mathematical ideas, which functioned as a motive that provided them with patience and persistence. It was envisioned that these experiences would function as a catalyst in the process of improving students' attitudes towards mathematics.

The methods course could be described as a typical 'teaching primary mathematics' course with half the topics concentrated on theoretical issues and the remaining on recent trends of teaching specific mathematics topics. All courses were one semester 3-credit-hour courses, taught in two one-hour lectures and one 'activity session' of one-and-a-half hours. The students were expected to take at least one course per year so that to complete the program by the end of the third year of their studies.

The intervention was of a longer duration than in previous studies, involving exposure to three courses, specially designed to facilitate attitude change. The target was to develop and implement a complete mathematics program and test its effectiveness. The following research questions were examined:

1. What are the attitudes towards mathematics of prospective primary teachers entering University Education programs?
2. Can the attitudes of candidate teachers be altered by mathematical experiences in their preparatory program?
3. Do changes in beliefs for preservice teachers vary by individual characteristics?

METHODOLOGY

A 'pre-test, treatment, post-test' research design was adopted. The subjects' attitudes were measured through a period of three years, prior to exposure to the program (phase 1), after the first course (phase 2), and after the implementation of the entire program (phase 3).

Instrumentation. Three complementary scales were used: the *Dutton's Attitude Scale* (Dutton, 1988), the *Self-rating Scale*, and the *Justification Scale* (Smith, 1988). Dutton's scale consisted of 18 statements reflecting feelings towards mathematics ranging from extreme negative to most positive; it was translated into Greek and slightly adapted to suit the cultural environment. The statements were randomly arranged to avoid recognition of patterns by attitude level (weighing factors were assigned by Dutton using the 'expert group opinion' technique, see Table 1). The subjects were called upon to endorse all those items in agreement with their own feelings.

The Justification scale consisted of two parts with ten statements each, providing possible explanations for liking and for disliking mathematics, respectively (Table 3). The subjects were allowed to endorse as many reasons as felt appropriate. The Self-rating was an eleven point linear scale, on which the subjects indicated their overall feelings about mathematics by drawing a circle around the point corresponding to their attitudes (1-absolute detest, through 6-neutral to 11-real love).

Finally, ten semi-structured interviews were carried out, about a few months after the completion of the program, to elicit deeper and additional information. Participants were randomly selected to include all levels of achievement. During the 45-min interviews the students were encouraged to give their own evaluations on: (i) their feelings about mathematics prior to University studies, and (ii) the effectiveness of mathematical experiences they had in the University, as related to attitudes.

Participants. The instrument was administered to all first year prospective primary teachers enrolled at the University of Cyprus ($N = 162$), during 1992, just before the beginning of the first mathematics content course. The same instrument was re-administered in 1993, when they completed their first course ($N = 137$), and finally in 1995 to those who completed all three courses ($N = 128$). Nearly 91% of the subjects were females, because they were the first students of the University and successful male student candidates had to complete military service prior to university studies; their ages at the beginning of the course varied from 18 to 21 years. The Department of Education is highly competitive due to immediate employment of graduates as primary teachers and thus freshmen are usually selected from among the top 25% quartile. Nonetheless, about one third of the students come from the Classical Section, where they take only core mathematics, and about two thirds of successful candidates prefer to avoid taking mathematics at the entrance examinations (its an optional subject).

RESULTS AND DISCUSSION

The results are presented and discussed for each phase with respect to students' responses on each item of the Dutton and the Justification scales. The points of the self-rating scale were grouped together into five levels: 1 and 2, indicated extremely negative attitudes, 3, 4, and 5 negative, 6 neutral, 7, 8, an 9 positive, while 10 and 11 indicated real love for mathematics. Two statistical techniques were used to detect patterns in attitude change and compare the subjects' responses in the three phases: the χ^2-test was applied, separately for each item of the Dutton scale, for each item of the Justification scale, and for specific responses of the self-rating scale. The *Median Polishing Analysis* (Velleman and Hoaglin, 1981) was applied on the responses to three specific aspects of the Dutton Scale.

ATTITUDES BROUGHT TO TEACHER EDUCATION

The pre-test measurements with the *Dutton scale* (Table 1) revealed an alarmingly high proportion of students who brought very negative attitudes to Teacher Education. At the entrance level 24% of the subjects stated plainly that they 'detest mathematics and avoid using it at all times', 28% declared 'I had never liked mathematics', and 14% reported that they 'have always been afraid of mathematics'. The proportions reported by Smith (1988) and Dutton (cited in Smith,1988) on the first two items were lower than 10%. On the other side, 15% of the subjects stated that 'mathematics thrills me and I like it better than any other subject', but this is by no means a compensation for the high proportion of those holding negative attitudes.

Further inspection of Table 1 would also suggest that many subjects at phase 1 endorsed rather neutral statements. For instance, 62% selected the item 'I do not think mathematics is fun, but I always want to do well in it', which may reflect the view that although mathematics is not their favorite subject, they realize the necessity to study them because of societal and cultural pressures. Similarly, 53% of the subjects reported that 'they enjoyed problems, when they knew how to do them', reflecting that success in mathematics is associated with positive feelings towards the subject, while the lack of confidence in doing problems is associated with negative attitudes.

The same pattern of responses also appeared in the Self-rating scale. Table 2 shows that 33.5% of the subjects entered their studies with negative attitudes, 7.5% were found to be neutral, and only 59% rated themselves on the positive side. The extended neutral region of the scale, that is the interval 6 ± 1, was selected by 24% of the students. This is not compatible

TABLE 1

Responses on the Dutton Scale in each of the three phases

	Attitude statements	Ph. 1	Ph. 2	Ph. 3	χ^2	p
1[1] (1,0[2])	I detest mathematics and avoid using it at all times	24	12	12	10.3	0.00
2 (1,5)	I have never liked mathematics	28	21	18	4.3	0.11
3 (2,0)	I am afraid of doing word problems	15	31	24	9.8	0.20
4 (2,5)	I have been always afraid of mathematics	14	19	13	2.4	0.00
5 (3,3)	Mathematics is something you have to do even though is not enjoyable	39	42	58	10.7	0.00
6 (3,7)	I do not feel sure of myself in mathematics	47	35	42	4.3	0.11
7 (4,6)	I do not think mathematics is fun, but I always want to do well in it	62	50	60	5.1	0.07
8[3] (5,3)	I'm not enthusiastic about mathematics, but I have no real dislike of it	30	29	42	6.3	0.04
9 (5,6)	I like mathematics, but I like other subjects as well	20	36	36	11.6	0.00
10 (5,9)	Mathematics is as important as any other subject	32	60	64	37.3	0.00
11 (6,7)	I enjoy doing problems, when I know how to do them	53	69	66	9.0	0.00
12 (7,0)	Sometimes I enjoy the challenge presented by a mathematics problem	43	65	61	16.5	0.00
13 (7,7)	I like mathematics because it is practical	34	55	43	13.0	0.00
14 (8,6)	I enjoy seeing how accurately and rapidly I can work on mathematics problems	33	40	52	10.8	0.00
15 (9,0)	I would like to spend more time at school working on mathematics	11	26	18	11.6	0.00
16 (9.5)	I enjoy working and thinking about mathematical problems outside of school	20	40	40	18.3	0.00
17 (9,8)	I never get tired of working with mathematics	19	31	27	6.3	0.04
18 (10,5)	Mathematics thrills me and I like it better than any other subject	15	29	16	6.3	0.04

[1]The items of this scale were randomly arranged in the questionnaire as: 16, 6, 14, 9, 13, 7, 8, 10, 5, 12, 3, 15, 1, 11, 18, 4, 17, 2.
[2]Numbers in brackets represent the weighing factors assigned by Dutton.
[3]Item 8 was omitted from the Median Polishing Analysis as neutral.

TABLE 2
Responses on the self-rating scale

Attitudes	Phase 1		Phase 2		Phase 3	
	N	%	N	%	N	%
Detest (1 and 2)	23	14.3	10	7.3	4	3.1
Negative (3, 4, and 5)	31	19.2	19	13.8	23	18
Neutral (6)	12	7.5	13	9.5	10	7.8
Positive (7, 8, and 9)	64	39.8	46	33.5	56	51.6
Real love (10 and 11)	31	19.2	49	35.8	25	19.6
Total	161	100	137	100	128	100

with related results found in the United States (Dutton, 1962; Smith, 1968; Reys and Delon, 1988), where the lower extreme proportions were by far lower than the proportions found here.

Table 3 summarizes the responses in each of the three phases on the Liking and the Disliking part of the Justification Scale. The most frequently mentioned reasons for liking mathematics were: ‘it develops mental abilities’ (47%), ‘it is practical and useful’ (39%), ‘it is interesting and challenging’ (35%), and ‘it is necessary for modern life’ (35%). On the other hand, the primary reasons for disliking mathematics were ‘I was afraid of it’ (29%), ‘because of poor teaching’ (27%), and ‘lack of teacher enthusiasm’ (25%).

CHANGES IN ATTITUDES

The comparison of responses between the three phases by the χ^2-test revealed significant differences in attitude ($p \leq 0.05$) on 14 out of 18 statements of the Dutton’s Scale (Table 1), and on 9 out of 10 items of the Liking part of the Justification Scale (Table 3). Clearly, fewer subjects in phases 2 and 3 than in phase 1 endorsed negative statements (1 and 2), while more subjects endorsed positive statements (12, 13, 14, 15, 16, and 17). Specifically, the proportion of those who ‘detest mathematics’ dropped from 24% to 12% and of those who ‘never liked mathematics’ from 28% to 18%. Conversely, the proportion of those who ‘enjoy working and thinking about mathematics outside school’ raised from 20% to 40%, and the proportion of those who ‘never get tired of working with mathematics’ from 19% to 27%. The increase on items 3 and 5 indicates a change of attitudes in the negative direction.

TABLE 3

Responses on the justification scale

Reason	Phase 1		Phase 2		Phase 3		χ^2	p
	N	%	N	%	N	%		
Reasons for liking mathematics								
I like mathematics because...								
it is interesting and challenging	57	35	78	57	66	53	16.3	0.00
it is necessary for modern living	57	35	67	49	96	76	47.1	0.00
it is practical and useful	63	39	73	53	85	69	25.6	0.00
I can understand it	24	15	46	34	37	30	15.9	0.00
it gives a feeling of accomplishment	55	34	65	47	54	44	6.1	0.04
it is fun	25	15	34	25	26	21	16.3	0.00
it develops mental abilities	76	47	93	68	92	72	23.3	0.00
I used to have good teachers	39	24	43	31	35	30	2.2	0.33
it is logical	47	29	58	42	62	50	13.6	0.00
it is rewarding	39	24	52	38	41	33	6.9	0.03
Reasons for disliking mathematics								
I do not like mathematics because ...								
of lack of understanding	39	24	23	17	23	19	2.5	0.28
of word problems	35	22	22	16	21	18	1.8	0.45
I have never done well in it	34	21	27	20	22	19	0.3	0.87
of poor teaching	43	27	27	20	38	31	4.2	0.12
of lack of teacher enthusiasm	41	25	25	18	48	39	14.2	0.00
it was never related to real life	25	15	9	7	10	8	6.9	0.03
it requires too much thinking	27	17	15	11	13	11	2.8	0.24
it takes too much time	22	14	19	14	19	16	0.3	0.85
I was afraid of it	47	29	34	25	40	33	1.8	0.38
exercises were used as punishment	20	12	11	8	6	5	4.6	0.09

Significant differences were also observed in the proportion of students who endorsed nine of the ten positive statements on the Liking part of the Justification Scale. For instance, the proportion of subjects who liked mathematics because 'it is necessary for modern life' raised from 35% to 76%, 'it develops mental abilities' from 47% to 72%, and 'its logical' from 29% to 50%. Significant differences were also found in two items of the reasons for Disliking mathematics part, both indicating positive change.

It seems that more students were convinced about their teachers' 'lack of enthusiasm' at the end of the program rather than before (from 25% to 39%), and fewer students continued to believe that 'mathematics is never related to everyday life' (from 15% to 8%).

The positive change in attitudes was also affirmed by responses on the Self-rating scale (Table 2). The proportion of subjects who detest mathematics dropped from 14.3%, at the entering stage, to 7.3% in phase 2, and to 3.1% in the phase 3. The overall decrease of those with negative attitudes was statistically significant ($\chi^2 = 22.5$, $p \leq 0.01$). The proportion of neutral subjects remained rather constant, while the proportion of students with positive attitudes raised from 39.8% in phase 1 to 51.6% in phase 3. A temporary enthusiasm that occurred at the end of the first course might explain the increase of the proportion of subjects who indicated real love for mathematics in phase 2.

THE MEDIAN POLISHING ANALYSIS

The median polishing analysis partitions two-way tables into four interpretable parts: the Grand Effect (GE) indicates the typical response across all the items, the Row Effect (RE) tests for differences between responses in different rows (phases), the Column Effect (CE) reveals relative differences among the level of endorsement of items, and the interaction between rows and columns which contains the residuals. The latter represent the extent to which endorsement of these items cannot be explained by differences among phases or items, but represent unique patterns of responses by subjects to particular items. For the application of this analysis, the Dutton's scale was partitioned into three parts. The first focused on mathematics *anxiety*, the second on the *usefulness* of mathematics in daily life, and the third one on the *satisfaction* from mathematics. The mathematics anxiety part consisted of five items intended to measure the extent to which students feel insecurity and fear in doing mathematics, and find working with mathematics an unsettling or frightening experience. In this part of the scale endorsement means a higher level of anxiety or fear. The Utility part of the scale with four items addressed students' perceptions of the significance and usefulness of mathematics in society, and the satisfaction part with eight items measured the extent to which subjects view themselves as interested, motivated, and able to do mathematics.

Table 4 shows a general low endorsement of the anxiety part (GE = 21%), a rather high acceptance of the utility part (GE = 41%), and medium endorsement on the satisfaction part of the scale (GE = 34%). Change of responses, however, during the three phases as indicated by the RE in the

TABLE 4

Median polishing analysis of responses to Dutton scale

Responses on the mathematics anxiety part

Items	1	2	3	4	6	Row effects
Phase 1	6	4	−15	−5	0	3
Phase 2	−3	0	4	3	−9	0
Phase 3	0	0	0	0	1	−3
Col. effects	−6	0	6	−5	23	Grand effect = 21

Responses on the mathematics utility part

Items	5	7	10	13	Row effects
Phase 1	−2.5	8	−9	2.5	−4.5
Phase 2	−11.5	−16	7	11.5	7.5
Phase 3	2.5	−8	9	−2.5	9.5
Col. effects	−0.5	0.5	3.5	−1	Grand effect = 41

Responses on the satisfaction part

Items	9	11	12	14	15	16	17	18	Row effects
Phase 1	2	2	0	0	3	−2	6	4	−14.5
Phase 2	0	0	4	−11	0	0	0	0	3.5
Phase 3	0	−3	0	1	−8	0	−4	−13	3.5
Col. effects	−2	31	23	13	−12	2	−7	−9	Grand effect = 34

three parts of the Dutton scale show a consistent positive improvement of attitudes. Specifically, RE on the anxiety part shows a decrease from 3 to 0 and then to −3, meaning that there had been a positive development from each phase to the following. On the utility dimension, the negative value (−4.5) at the entering phase became positive in phase 2 (7.5) and was increased (9.5) in phase 3, indicating an improvement of attitudes. Finally, on the satisfaction part of the scale the significant negative value of −14.5 at phase 1 was improved by 17.5 units in the next two phases, indicating the development of sense of a satisfaction from mathematics. Thus, between the first and the final phase an improvement was observed which might be due to the exposure of students to the mathematics program.

The column effects indicated relative differences among the students' opinions on item 6 of the anxiety part and on items 11, 12, 14, and 15 of the satisfaction part. Students particularly affirmed the notion that they 'enjoy mathematical problems when they can solve them' (item 11, CE $=$ 31) and that they 'sometimes enjoy the challenge of mathematics' (item 12, CE $=$ 23). It is interesting to note that students in general were negative about 'spending more time in school working on mathematics' (item 15, CE $= -12$). This might be related to past experiences (lack of enthusiasm and poor teaching) as the term 'at school' might refer students to past experiences.

Interviews. The students were encouraged, during interviews, to describe their feelings prior and after their attendance of the program. It becomes clear that most of the subjects developed negative attitudes out of experiences at the high school, while the program courses and particularly the historical developmental element helped them change their feelings. Some indicative extracts from the interviews follow:

– 'My attitudes were extremely negative thanks to my teachers. Mathematics was for me a piece of work based on getting the right answer and most of the times I could not succeed'.

– 'The proper way to learn mathematics was by memorizing facts and procedures', ... 'any statement or answer in mathematics was either right or wrong'.

– 'When I entered the University I felt relief; I was happy, thinking that I had finished with mathematics. The moment I learned that the program of studies required 3 more courses in mathematics I felt frustration. I felt that mathematics will hunt me for ever'.

– 'History of mathematics provided me with a variety of interesting, new, experiences ... Through the journey I realized that mathematics has always been and continues to be a very useful subject ...I appreciated the efforts of people to use mathematics to solve daily problems. The course showed me that mathematics is, at least sometimes, a human activity. I felt more confident when I realized that even great mathematicians did mistakes as I frequently do'.

PREDICTORS FOR ATTITUDE CHANGE

To answer the last question of the study, i.e., to determine whether individual characteristics contribute to changes in attitudes, we selected a number of demographic variables such as sex, the education and occupation of students' parents, the type of high school (lyceum) from which students graduated, their grade-point averages at high school, and their grades in mathematics and language. The dependent variable used to answer the research question was a continuous variable measuring differences in the subjects' self reported attitudes on the eleven point linear scale, between phase 1 and phase 3. Specifically, the dependent variable was the difference between the student's point selection in phase 3 and his/her selection in phase 1. Positive values indicated increase in student attitudes during the exposure period, negative values indicated decline, and zero indicated stability.

Ordinary least squares regression analysis was used to examine for possible relationship between students' characteristics and changes in their attitudes. None of the predictors was found to be associated with change in students' attitudes, indicating that individual characteristics do not predispose preservice teachers to particular changes in their attitudes towards mathematics ($R^2 = 0.12$, $F = 0.64$, $p < 0.82$). This result reinforces the assumption that other variables such as the preparatory course contributes to the attitudes changes among beginning teachers. However, the lack of association between individual characteristics and attitude change might be due to the fact that all subjects had not started out equal, and thus the control for initial status strategy might led to a specification bias that makes difficult any attempt to draw safe conclusions about individual differences in change. This problem cannot be solved simply by including the observed pretest scores to control for initial status (Rogosa and Willett, 1985).

CONCLUSIONS

The results of this study seem to provide evidence that (a) prospective teachers bring to Teacher Education misconceptions and negative attitudes towards mathematics, and (b) mathematics preparatory programs provide an opportunity to influence attitudes positively.

Specifically, it was found that a considerable proportion of prospective teachers bring to the university negative feelings towards mathematics, a subject they will soon be supposed to teach. In most countries, teaching does not attract candidates highly motivated to learn and teach mathematics, and this trend is not likely to change in the foreseeable future. On the contrary, it seems that a proportion of teachers, will continue to view mathematics as a finished and dead discipline, teach along the traditional lines, and thus influence students and prospective teachers to develop negative attitudes; hence it will be the task of Education Departments to improve the situation.

In the present project, attitude change was sought as a by-product of the effort to develop mathematical understanding, by exploiting two special environmental factors which proved to be decisive: the establishment of a new department and hence the possibility to design a mathematics program from the beginning, and the historical heritage of the student population. At the end of the program changes in the attitudes of the students were evidenced by complementary instruments and several statistical analyses. Significant improvement of responses was found on 14 items of the Dutton scale as well as on the satisfaction, utility, and anxiety dimensions of the same scale. In addition, improvement was observed on the Justification scale (mostly the liking part), and on students' responses on the self-rating scale. According to students' judgment, the historical element of the courses played a major role in this change. It needs to be noted, however, that the present study did not disentangle several factors that might have been operative. One of these factors relates to the mental models that the program created in the students about mathematics. Another factor is the presence of the university instructors themselves and the way they implemented these models in the classroom. A final question, which is still open and remains to be answered, concerns the endurance of this change and its effect on actual teaching behavior.

Despite some negative change, indicated by items 3 and 5 (Dutton), we consider that students beliefs improved, though not to the extent to overcome deeply rooted anxiety about mathematics. This should not be surprising since most of students' feelings were formed over their entire school life and in many cases were the outcome of established prejudices of the social environment. It seems that some emotions in the mind of students are persistent to change, and additional time and more challenging experiences are required in order to override them. Nevertheless, given the significance of this attempted change, no effort is too much, particularly since the findings seemed to offer a light at the end of the tunnel, a hope and a means that might be effective to break down the vicious circle of attitude reproduction.

Change was found to be non-correlated to any of the subjects' characteristics tested, that is their gender, type of high school, mathematics performance, or family sociocultural conditions. This is a rather surprising finding and it needs further investigation. It would be very encouraging, if the program is really so powerful as to affect invariably the attitudes of students, irrespective of individual characteristics. This is probably too good to be true, yet irrespective of possible reservations, another window might have opened.

APPENDIX

A brief list of the main topics included in the content courses follows: (1) Prehellenic mathematics (emphasis on the number systems); (2) Thales and the first proof, the mathematics of the Pythagorean (figurative numbers, Pythagorean theorem, and the first crisis in mathematics); (3) The three famous problems of antiquity and some of their 'solutions'; (4) Euclid and the 'Bible of Mathematicians' (the postulate system, comments on the power and weaknesses of his mathematics); (5) Topics from the work of Archemides and the great astronomers (calculation and the history of the number π, the radius of earth-Eratosthenes); (6) Selected topics from the works of Heron, Diophandus and Pappus; (7) Eudoxus principle of Exhaustion and the concept of limit (the concept of derivative and integral with applications); (8) The liberation of geometry and some elements of hyperbolic geometry (the significance of letting axioms free from the idea that they are evidently true); (9) The liberation of algebra, examples of non commutative algebra and elements of matrix algebra; (10) Sets and binary relations (equivalence); (11) Logic truth tables; (12) Elements of Boolean algebra and logic gates.

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