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ELEMENTARY PRESERVICE TEACHERS' CHANGE

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Abstract: In the last two decades investigation of teachers' beliefs and conceptions and teachers'possibilities for change has been one of the points of emphasis in mathematics education. We propose the concept and design of an intervention program including five stakeholders on the basis of a teacher–student–parent–preservice teacher–teacher educator relation. The main idea is comprised of reversed roles in teaching and learning process i.e. elementary school preservice teachers should adopt belifs and conceptions from the mathematically promising students (age 6-12). The program is defined by 10 relationships among stakeholders and was evaluated from various viewpoints. In this paper, we highlight the effect on the preservice teachers' competencies during the longitudinal study. We have focused on the gap between desired and achieved competences as viewed by the preservice teachers. Overall results speak in favour of presented approach.

Zusammenfassung: In den letzten beiden Jahrzehnten war die Forschung über die mögliche Modellvorstellungen und Möglichkeiten der Lehrer im Bereich Mathematikerziehung sehr betont. Wir schlagen das Konzept und die Entwicklung eines geeigneten Ausbildungsprogramms vor, die Erweiterung von Beziehungen von Lehrer-Student-Eltern bzw. Lehrer-Lehrer. Die Hauptidee beinhaltet vertauschte Rollen im Lehr- und Lernprozess, d.h. Grundschullehrer sollten Glauben und Konzeptionen von den mathematisch begabten Studenten annehmen (Alter 6-12). Das Programm wird durch 10 Beziehungen unter Interessengruppen definiert und wurde nach verschiedenen Gesichtspunkten ausgewertet. In dieser Schrift betonen wir den Effekt auf die Kompetenzen der Lehrer während des hierarchischen Studiums. Unser Fokus ist auf der Kluft zwischen den gewünschten und erreichten Kompetenzen, wie von den Lehrern gesehen. Gesamtergebnisse sprechen zu Gunsten der gezeigten Annäherung.

Key words: mathematics education, teacher education, teacher change, program evaluation, promising students, lower primary.

1. Introduction

"Teacher change" is a well known term in literature, meaning a change in teachers' beliefs and conceptions concerning teaching and learning (Leder et al, 2003). Different intervention programs that can be helpful in challenging prospective teachers' beliefs were proposed with common denominator in emphasizing importance of teachers' acquaintance with students' ways of thinking (Carpenter et al, 1999; Tirosh et al, 2001). However, it is not very clear how to facilitate teachers, especially preservice teachers, to achieve that sort of acquaintance. It is our firm belif that they have to experience it in some kind of school setting.

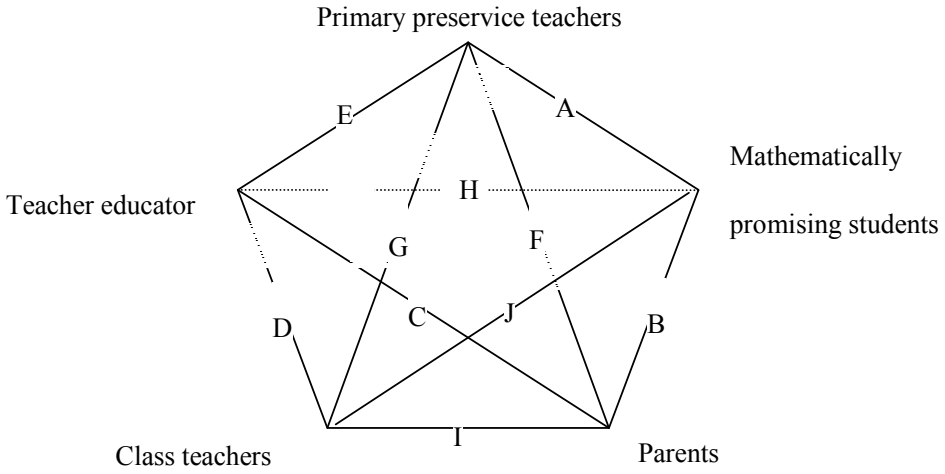
It is believed that in average mathematically gifted children have positive beliefs about and attitudes towards mathematics. Gifted students entering middle school have stronger mathematics self-concept beliefs and more accurate (less overconfident) self-efficacy beliefs than other students (Pajares and Graham, 1999). For elite students, when there was a causal relationship between attitude and achievement, achievement always claimed (unidirectional) causal predominance (Ma and Xu, 2004) over attitude. That is why we confronted preservice teachers with mathematically promising children in hope that confrontation will shape preservice teachers' attitudes or at least make them explicit.

The club activities mode has positive affect on beliefs about school subjects (Papanastasiou in Bottiger, 2004). Additional time spent on math club activities for instance, is linked with higher achievements at school subjects (Miller, 2001). Club activities foster cooperative learning, critical thinking and developing of an individual problem solving strategies (Mueller and Fleming, 2001).

Concept, design and impact of teacher change intervention program, which was built on these premises, will be described in following sections. We start with general framework for describing work in the program called Didactic Pentagon (program logic model), proceed with results of three empirical program impact studies and conclude with open problems.

2. Program logic model

Didactic Pentagon is an experimental program for preservice teachers, based on field experiences strengthening the connection between subject course and classroom work. The program includes all crucial participants of the school environment on the basis of a teacher–student–parent–preservice teacher–teacher educator relation. Program is defined through 10 relationships. (Picture 1.).



Picture 1. *Didactic Pentagon.*

The only indirectly realized relationship is teacher educator - mathematically promising student (relationship H) since educator is not directly involved in learning process. He/she only organizes a situation in which the process of teacher change could happen. All other relationships work in direct manner through Pentagon activities. Relationships I and J are part of school routine so we won't describe them. Preservice teachers work with students (relationship A) one hour per week during the whole year in mode of club activities. Activities are performed throughout the school year following prewritten curriculum. Open-ended problems are introduced at club meetings and then left to individual work until next session. Students and their parents (relationship B) work together in finding possible solutions which are discussed at the next meeting.

Relationships F and C are realized at regular parent meetings of two types. The first type is held regularly every month and it is planed, prepared and guided by preservice teachers. Type 1 (relationship F) parent meetings confront preservice teachers with some forms of work with parents. Class teachers and teacher educators also participate at parent meetings, but in a more passive form. These two participants take an active part in parent meetings of type 2, which take place in form of lectures and afterward discussions. Type 2 (relationship C) meetings are intensively held at the beginning and at the end of a school year. Their main aim is to inform parents about the ways they could help their children. Meetings also try to insure that transmission methods of learning which are plausible at relation B don't take place. Relationship E has many forms connected with regular program of preservice teacher training (lectures, fieldwork, video case analysis, research simulation, peer teaching). Class teachers and prospective primary teachers (relationship G) meet on weekly basis to discuss progress of the students and some other practical problems. Relationship D is more informal in nature and usually takes place after parent meetings. This relationship fulfils two aims: to insure class teacher that there is no doubling in subject matter according to curriculum and to properly guide

preservice teachers in school settings. Relationship D also provides teacher educator with some basic information about reactions on implementation of program.

3. Former evaluations

Program evaluators may assess programs on several dimensions to determine whether the program works. Program started in year 2002, until present it included more then 1300 students and about 70 preservice students. Only results in some performance areas of Didactic Pentagon were gathered and analyzed so far. Key performance indicators were set according to program stakeholders (impact on students, preservice teachers, parents etc.). Perhaps the most difficult part of program evaluation is determining whether the program itself is causing observed impacts. Therefore longitudinal research has been implemented in two fields – students' mathematical knowledge and teacher change. In following studies regarding children's creativity quotient, children's mathematical knowledge and (more detailed) teacher change will be described.

Mathematical knowledge (N=127) was assessed in 2005 using two comparable batteries of TIMSS 2003 items. At initial test the average result was 68%. Final average result after three months advanced to 80%. Since results can be developmentally distorted, the comparability with mathematically promising students in the whole population of Slovenia was also made. Results of TIMSS 2003 study were used in order to form a control group. Pentagon group has surpassed this control group in overall result for about 7% which is more that can be assigned to developmental change or school influence. Important differences in favour of experimental group were, among others, found at problem solving cognitive domain i.e applying knowledge and understanding.

The "children's creativity" research in year 2004 involved N=318 students (age 8-11). Creativity quotient was determined through the scoring method proposed by Snyder et al (2004). The method is based on intuitive idea that answers, given on free word-associative test, can not be weighted equally. To obtain the creativity quotient it is first necessary to partition all the responses into different categories. To avoid problems concerning subjectivity of partitioning results in different categories, results were obtained by averaging results of two independent scorers. Significant differences in creativity quotient were observed between Pentagon students and mathematically promising students not included in program. (Lipovec and Bezgovšek, 2006).

4. Methods

The scope of research regarding preservice teacher change was to acknowledge whether the gap between desired and achieved preservice teachers' competencies during the longitudinal study, diminished. Longitudinal study was conducted to depict impact participation in program had on preservice students. We compared the data in several possible ways: data concerning preservice teachers involved in Didactic Pentagon program against those, who were not involved; data of initial testing against those of final testing; data regarding solely preservice teachers involved in Didactic Pentagon program; data of initial and final test of preservice teachers involved in program. Our initial hypotesis was that differences between desired and achieved preservice teachers' competencies will diminish during the longitudinal study lasting for a year.

We tested the same population, with the same questionnaire twice in almost eight month interval. Initial test was performed in November 2005 – it included 241 respondents (N1=241). Final test was performed in June 2006 and included 102 respondents (N2=102). There were 343 respondents in both tests (N=343). In initial test were 38 respondents (N1c=38), which had worked with mathematically promising students in math clubs, and 15 suchlike respondents were in post-test (N2c=15).

For the purpose of exploring the preservice teacher's competencies, we conducted the questionnaire, which contained two major parts: first part questioned the respondents about desired competencies on elementary level of teacher education and the second part questioned them about achieved competencies in their education. Each part of questionnaire included 46 paired questions, together 92

questions. The intensiveness of questionnaire i.e. the number of items was deliberately so high in order to prevent socially desired answers. Kaiser-Meyer-Olkin test guarantees appropriate sampling (initial test: KMO = 0.838, $p<0.001$; final test: KMO = 0.413, $p<0.001$). Data were normalized according to Kolmogorov-Smirnov by Bloom method; Cronbach's Alpha values after normalization were high enough to proceed with statistical processing (initial test: $\alpha = 0.944$, post-test: $\alpha = 0.959$).

5. Results

Pentagon preservice teachers had indicated higher grades of importance in all answers in both tests. This is the first important and eloquent information about both groups. In the initial test the differences between experimental and control group appeared in eleven questions: skilfully use of various math tools, teaching through playing, contextualization of math tasks, math in everyday settings, assessments, the applicable use of mathematical discourse, methodical skills in contents on natural numbers and measurement, team work, an aspiration for lifelong learning and permanent education and the capability of organizing and leadership. The four differences that appeared in post-test are: applicable use of mathematical discourse, an aspiration for lifelong learning and permanent education, the knowledge about philosophical and historical facts about educational policy and their practical use and the ability to take an active part in school politics. The differences between variance of both groups and between means of both groups were important in two paired questions: applicable use of mathematical discourse ($t(57) = -2.28$, $p<0.05$ initial test and $t(61) = -2.11$, $p<0.05$ at final test) and in aspiration for lifelong learning and permanent education ($t(81) = -3.51$, $p = 0.001$ in first part and $t(84) = -6.15$, $p < 0.001$ in second part of questionnaire). The differences that appeared in final test are in areas of creating a comfort class climate, prealgebraic and combinatorial representations, measurement and geometry and lifelong learning in first part. There were two differences in second part: fraction and combinatory situations. None of the final test differences were statistical important. Initial test showed important difference between preservice teachers included in Pentagon project (experimental group) and control group. Differences were found on communication level (applicable use of mathematical discourse) and the need for lifelong learning and permanent education. Differences between desired and acquired competencies have changed because of their involvement in Pentagon program. At initial testing important differences occurred in following domains: use of various math tools ($t(29) = 4.18$, $p < 0.001$), contextualizing math contents ($t(30) = 4.59$, $p < 0.001$) methodological approaches in natural numbers ($t(25) = 3.14$, $p < 0.005$). The final test important differences were found at domain of measurement ($t(13) = 2.40$, $p < 0.5$).

As could be predicted, the gaps between desired and achived competencies were always negative; i.e. the desired abilities and competences were rated higher as the achived ones. More specific analyse was conducted on the gap between them comparing preservice students from Pentagon project with students who did not take part in the program. Four data groups (from questions) differed significantly from others: application of didactic tools and games at math classes (Mann-Whitney $U = 144.000$, $p =0.004$); appropriate and efficacious didactic implementation of ICT ($U = 148.000$, $p =0.004$); providing appropriate feedback information to students ($U = 125.000$, $p =0.001$); ability of team work and cooperation ($U = 105.500$, $p =0.000$).

In all cases respondents rated higher values in final test, what shows us that they became more aware of importance in these cases and they started to feel more confident in mentioned data groups. Differences became significant only in mentioned data groups, but the tendency of Pentagon preservice teachers' change is shown in means of all cases, by giving higher ratings at final test.

6. Discussion

The results clearly show us the positive influence of program on preservice teachers. Only on two fields the gap got bigger and both of them refer to decimal numbers. The reason lies in absence of that subject in Slovenian school curriculum and therefore also at teacher training courses. Preservice teachers became more aware of importance of application of didactic tools and games at math classes, appropriate and efficacious didactic implementation of ICT, providing appropriate feedback information to students and in ability of team work and cooperation.

Didactic tools and games probably became more important to them, because they have learned how to use particular tool (for instance Cuisenaire rods) or game (like Tangram) and found out their applicability in classroom. ICT as the ultimate need for present time was also included in the program through e-learning materials for students. Since preservice teachers worked with students for longer period of time, the need for appropriate feedback information became evident. Confidence is very important personal characteristic, especially for future teachers and the program gave that quality to them, so we made a big step forward. If someone, whom schooling lasted for at least 16 years, steps in a class and finds out (or worse – the students find out) that he/she doesn't have enough self confidence to lead the class and beside that he/she feels the lack of support in their beginning careear, can became in great distress (Avalos and Aylwin, 2007). We wanted to create a rich informational interaction among the most important elementary school subjects with key influence on shaping a democratic, compromising, and coherent educational system. The program has design that only work in communitiy with rich background informational interaction, therefore the awareness of need for team work was plausible in this situation.

7. Conclusion

The main idea of presented program is that elementary school preservice teachers should confront with mathematically promising children at club activities mode in order to change theirs beliefs and attitudes regarding mathematics. Preservice teachers should not only become more sensitive to children's mathematical thinking, in optimal case, preservice teachers should adopt some epistemological beliefs held by mathematically promising students.

Cooperation of elementary schools and faculties in context of the knowledge and experiences exchange is more and more important for the quality improvement of both institutions. The anticipated short- and long-term effects of Didactic Pentagon program speak in favour of presented approach. So far we have focused on two main stakeholders – students and preservice teachers. In the future the impact of the program on remaining stakeholders (parents, teacher educators and class teachers) has to be determined. We believe that Pentagon program represents some new approaches and solutions that will hopefully help to add new dimensions to the cooperation practiced so far.

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