DO FUTURE TEACHERS' DEMOGRAPHIC CHARACTERISTICS INFLUENCE THEIR ATTITUDES ABOUT THE NATURE, LEARNING AND ACHIEVEMENT IN MATHEMATICS?

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ABSTRACT:

Teachers' professional beliefs on what is mathematics, how mathematics is learned, and who is capable of learning mathematics have a significant mediating effect on teachers' success in providing pupils with genuine opportunities to learn meaningful mathematics. An empirical study exploring the relations between a set of demographic characteristics of future primary school and pre-school teachers and their declared beliefs about the nature of mathematics, learning mathematics and mathematics achievement was conducted on a sample of university students. The sample consists of students in their final year of university studies in primary teacher education, pre-school education, and pedagogy, recruited from all four Macedonian universities offering these study programs (N=161). The basic data collecting tool was a questionnaire consisting of items taken and adjusted from the TEDS-M study.

Data analysis (Mann-Whitney U and Kruskal-Wallis H nonparametric tests, IBM SPSS 20) suggest that gender, language of studies, parents' education levels, as well as respondents' secondary education may play a role in certain aspects of future teachers' beliefs about mathematics, which they tend to profess: understanding mathematics as a process of inquiry or as a set of rules and procedures to be remembered. Results on a mathematics item designed specifically to probe whether future teachers provide responses consistent with the beliefs that they endorsed are in line with research in the field. Existing literature indicates that the interpretation of these findings requires viewing them as components of a complex system of knowledge (in particular, mathematics content knowledge) and professional beliefs. Some implications on how to plan and implement mathematics courses for primary school teachers and pre-school teachers aimed at developing the required professional beliefs to successfully support the development of mathematical thinking of young learners are discussed.

Key words: mathematics education, professional beliefs, gender, language of studies, study program, parents' education level.

INTRODUCTION

There is a certain level of agreement within the mathematics education research community (Blцmeke & Delaney, 2012) that the conceptual framework of teacher competencies is comprised of two main components: cognitive abilities, i.e. professional knowledge, and affective motivational characteristics. Teachers' professional beliefs, motivation and self-regulation have a direct influence on how teachers access their knowledge base (e.g., mathematics content knowledge, mathematics pedagogy content knowledge) in their instructional practices (Blцmeke, 2012; Blцmeke & Delaney, 2012; Schoenfeld, 2011; Schoenfeld & Kilpatrick, 2008; Shulman, 1986, 1987). Research evidence (Polly, McGee, Wang, Lambert, Pugalee, & Johnson, 2013; Stipek, Givvin, Salmon, & MacGyvers, 2001) reveals that there are consistent associations between teachers' beliefs and their instructional practices. Acknowledging that there are challenges related to an assessment of teacher education effectiveness when an educational-psychological perspective (rather than an educational-sociological one) is taken (Blцmeke, Felbrich, Mьller, Kaiser, & Lehmann, 2008), it is worthwhile examining whether some demographic characteristics of future teachers influence aspects of their professional beliefs.

METHOD

An empirical study exploring the relations between a set of demographic characteristics of future primary school and pre-school teachers and their declared beliefs about the nature of mathematics, learning mathematics and mathematics achievement was conducted on a sample of university students at the end of their final semester of university studies in primary teacher education, pre-school education, and pedagogy, recruited from all four Macedonian universities offering these study programs (N=161). The demographics, as provided by the respondents, are:

- Gender: 81.4 % female, 16.2 % male, 2.5 % non-response;
- Study language: 46.6 % Macedonian, 47.8 % Albanian, 5 % Turkish, 0.6 % non-response;
- Study program: 78.3 % primary teacher education, 17.4 % pre-school teacher education, 2.5 % pedagogy, 1.9 % non-response;
- Mothers' education level: 33.5 % basic (primary and lower secondary), 49.7 % upper secondary, 14.9 % tertiary education, 1.9 % non-response;
- Fathers' education level: 17.4 % basic (primary and lower secondary), 53.4 % upper secondary, 27.3 % tertiary education, 1.9 % non-response;

- Type of secondary education: 55.3 % general, 42.2 % vocational, 2.5 % non-response;

- Secondary grades average: 52.2 % A, 36.7 % B, 8.7 % C, 0.6 % D, 1.9 % non-response.

The basic data collecting tool was a questionnaire consisting of items taken and adjusted from the International Association for the Evaluation of Educational Achievement (IEA) *Teacher Education and Development Study in Mathematics* (TEDS-M) (Tatto, Schville, Senk, Ingvarson, Peck, & Rowley, 2008). The research hypotheses are of a differential type, based on the structure of the measuring instrument and on the planned crossovers of the obtained data with the demographic variables. We hypothesized that gender, language of studies, parents' education levels, as well as respondents' secondary education (type and grade average) play a role in future primary school teachers' and pre-school teachers' beliefs about the nature of mathematics, learning mathematics, and mathematics achievement, as well as on their responses on a given mathematics problem. Each auxiliary hypothesis is discussed in details in the Results section.

The survey beliefs scales: The survey beliefs scales were adopted from TEDS-M, considered to be the first cross-national study to provide data on the knowledge (including beliefs) that future teachers acquire during their teacher education (Ingvarson, Schville, Tatto, Rowley, Peck, & Senk, 2013; Tatto, Peck, Schville, Bankov, Senk, Rodriguez, Ingvarson, Reckase, & Rowley, 2012; Tatto, Senk, Rowley, Peck, 2011). The Likert-type scales offered the respondents six options: strongly disagree, disagree, slightly disagree, slightly agree, agree, and strongly agree. The statements included in the questionnaire covered three areas of teachers' beliefs: 1. Beliefs about the nature of mathematics (mathematics is a set of rules and procedures enquiry – 6 statements, mathematics is a process of enquiry – 6); 2. Beliefs about learning mathematics (mathematics is learned through teacher direction enquiry – 8, mathematics is learned through active learner's involvement enquiry – 6); and 3. Beliefs about mathematics achievement (mathematics is a fixed ability – 8) (for detailed description, see Tatto et al, 2012). The statements were taken in their entirety from the *Sample items for Beliefs about Mathematics and Mathematics Teaching* (Tatto et al., 2008, p. 89-91). These statements represent views loosely related to conceptual versus calculational orientations, and cognitive-constructivist versus direct transmission views of learning. A comprehensive review of mathematics teachers' beliefs and affect, as well as orientations, is given by Phillip in Chapter 7 of the *Second Handbook of Research in Mathematics Teaching and Learning* (Lester (ed.), 2007).

The mathematics item: Only one mathematics item was included in the questionnaire due to the length of the beliefs survey and the perception of the authors that the respondents would be reluctant to respond to a number of mathematics items. Respondents were asked to choose the method most likely to be used by grade 5 (10-11 years old) pupils in finding the area of a triangle with vertices on three sides of a grid composed of unit squares, among the following:

A. Directly using the formula for the area of a triangle $A = \frac{a \cdot h_a}{2}$;

B. Using Pythagoras's Theorem $a^2 + b^2 = c^2$ to calculate the lengths of the sides *a*, *b*, *c* of the triangle, then using Heron's Formula for the area of a triangle $A = \sqrt{S \cdot (S-a) \cdot (S-b) \cdot (S-c)}$, $S = \frac{a+b+c}{2}$;

C. Using the Distance formula $d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$ to calculate the lengths of the sides *a*, *b*, *c* of the triangle, then using Heron's Formula for the area of a triangle $A = \sqrt{S \cdot (S-a) \cdot (S-b) \cdot (S-c)}$, $S = \frac{a+b+c}{2}$;

D. Finding the areas of the three rectangular triangles outside the triangle by halving the number of unit squares in the three corresponding rectangles, then subtracting the sum of these areas from the area of the whole grid;

E. Other _____

This item was inspired by TEDS-M multiple-choice MCK item *MFC408* (Tatto, et al., 2012).

RESULTS

Beliefs about the nature of mathematics

The results show that male and female students differ in their beliefs about the nature of mathematics. The statistical Man-Whitney nonparametric test ($Z=2.121$, $p<.05$) confirms that male respondents to a higher degree than their female colleagues express dependence on knowing the exact procedure in order not to feel lost when solving a mathematical task.

Students studying in different languages of instruction differ in their beliefs about the nature of mathematics. The statistical Kruskal-Wallis

nonparametric test (χ^2=7.727, df=2, p<.05) confirms that future teachers studying in Macedonian language to a lower degree than their colleagues studying in Albanian or in Turkish language support the belief that they rely on knowing the exact procedure when solving a mathematical task. At the same time, future teachers studying in Macedonian language also to a lower extent express the belief that when engaging in mathematical tasks they can discover new things (connections, rules, concepts) (χ^2=6.630, df=2, p<.05). Respondents studying in Turkish language to a higher extent than their colleagues in studying in Macedonian or in Albanian language support the statement that extensive practice, correct application of routines, and problem solving strategies is required for doing mathematics (χ^2=9.547, df=2, p<.01), as well as the statement that mathematics means learning, remembering and applying (χ^2=7.945, df=2, p<.05).

There was no statistically significant difference found between the beliefs endorsed by students of different study programs (primary school teacher education, pre-school teacher education, and pedagogy) about the nature of mathematics.

Parents' education appears to be a significant factor in students expressed beliefs about the nature of mathematics. Lower educational levels of mothers predisposed students to support the beliefs that knowing the exact procedure when solving a mathematical task is important (χ^2=7.260, df=2, p<.05). On the other hand, respondents whose fathers have attained only primary education levels are more predisposed to endorsing the belief that new thing can be discovered when engaging in mathematical tasks (χ^2=6.952, df=2, p<.05).

The type of secondary education (general or vocational) acquired by the respondents was not confirmed to play a role in their expressed beliefs about the nature of mathematics. Also, it was not confirmed that respondents' secondary education grade average had any influence on their endorsement of various statements about the nature of mathematics.

Beliefs about mathematics learning

The hypothesis that students of different gender differ in their endorsement of various beliefs about mathematics learning was not confirmed. Language of instruction appears to be a significant factor in respondents' disposition towards endorsing certain statements about mathematics learning. Respondents enrolled in teacher education studies in Macedonian language of instruction are less prone than their colleagues who study in Albanian or in Turkish language of instruction to endorse the view that to be good in mathematics one needs to be able to solve

problems quickly, as confirmed by the statistical Kruskal-Wallis nonparametric test (χ^2=8.669, df=2, p<.05). Future teachers studying in Macedonian language of instruction also to a lesser extent than their colleagues studying in Albanian or in Turkish study language support the view that when pupils work on mathematical problems, more emphasis should be put on getting the correct answer than on the process followed (χ^2=13.352, df=2, p<.01). In line with these findings, the statistical Kruskal-Wallis nonparametric test (χ^2=7.568, df=2, p<.01) confirmed that respondents in Albanian study language to a lower extent than their colleagues in Macedonian or Turkish study language endorse the belief that in addition to getting a right answer in mathematics, it is important to understand why the answer is correct. Future teachers in Turkish study language to a higher degree than their colleagues in Macedonian or in Albanian study language express believing that pupils' non-standard procedures should be discouraged because they can interfere with learning the correct one (χ^2=8.217, df=2, p<.05). At the same time, future teachers in Turkish study language to a higher degree support the belief that time used to investigate why a solution to a mathematical problem works is a time well spent (χ^2=8.190, df=2, p<.05). The statistical Kruskal-Wallis nonparametric test (χ^2=5.795, df=2, p=.055) signals a feebly expressed tendency that respondents in Turkish study language to a higher degree than their colleagues in Macedonian or in Albanian study language endorse the belief that it is helpful for pupils to discuss different ways for solving mathematical problems.

The auxiliary hypothesis that there are differences in the beliefs about mathematics learning endorsed by students of different teacher education programs was not confirmed.

Parents' education levels were not proven as being a significant factor in the levels of endorsement of various beliefs statements about mathematics learning.

The type of secondary education acquired by the future teachers in the sample did appear to play a role in their endorsement of some statements about mathematics learning. The statistical Man-Whitney nonparametric test (Z=2.038, p<.05) confirms that respondents with vocational education to a higher degree than their colleagues with general education support the belief that pupils learn mathematics best by attending to teacher's explanations.

The secondary grade average also appeared to be a factor in future teachers' disposition towards supporting certain beliefs about mathematics

learning. The statistical Kruskal-Wallis nonparametric test (χ^2=11.445, df=3, p<.01) confirms that future teachers who reached lower secondary grades average (equivalent to C and D) to a higher degree than their colleagues endorse the belief that hands-on mathematics experiences are not worth the time and expense.

Beliefs about mathematics achievement

Gender plays a role in future teachers' endorsement of beliefs about mathematics achievement as a fixed ability. The statistical Man-Whitney nonparametric test (Z=3.052, p<.01) confirms that male respondents to a higher extent than their female counterparts endorse the belief that, in general, boys tend to be naturally better at mathematics than girls. A weakly expressed tendency of male students to support to a higher degree than their female colleagues the belief that the use of hands-on models and other visual aids becomes less necessary with older pupils since they can reason abstractly is almost detectable by the statistical Man-Whitney test (Z=1.889, p=.059).

Study language also plays a role in future teachers' endorsement of the view of mathematics as a fixed ability. The statistical Kruskal-Wallis nonparametric test confirms that future teachers studying in Macedonian language to a lower extent than their colleagues in Albanian or in Turkish study language endorse the beliefs that: to be good at mathematics one needs to have a kind of "mathematical mind" (χ^2=6.689, df=2, p<.05), mathematics is a subject in which natural ability matters a lot more than effort (χ^2=26.101, df=2, p<.000), only the more able pupils can participate in multi-step problem solving activities (χ^2=10.174, df=2, p<.01), and some ethnic groups are better at mathematics than others (χ^2=8.802, df=2, p<.05). The statistical Kruskal-Wallis nonparametric test also confirms (χ^2=9.785, df=2, p<.01) that future teachers studying in Turkish language to a higher degree than their colleagues support the belief that boys tend to be naturally better at mathematics than girls. Future teachers studying in Albanian language to a higher extent than their colleagues endorse the belief that some people are good at mathematics and some aren't (χ^2=11.644, df=2, p<.01).

The type of teacher education program was not confirmed to play a role in the extent to which future teachers endorse the view of mathematics as a fixed ability.

The extent to which future teachers endorsed beliefs consistent with the view of mathematics as a fixed ability differed depending on different levels of parents' education. The statistical Kruskal-Wallis nonparametric

test (χ^2=14.913, df=2, p<.01) confirms that respondents whose mothers have completed only basic education (primary and lower secondary) to a higher degree than their colleagues supported the view that mathematics is a subject in which natural ability matters a lot more than effort. It was almost close to be confirmed (χ^2=5.686, df=2, p=.058) that the lower the education level of the mother, the higher the endorsement of the belief that some people are good at mathematics and some aren't.

The hypothesis that the type of secondary education plays a role in the extent to which future teachers endorse beliefs reflecting the view of mathematics as a set ability was not confirmed.

The secondary grade average appears to be a factor which makes a difference in the degree to which future teachers support some statements consistent with the view of mathematics as a fixed ability. The statistical Kruskal-Wallis nonparametric test (χ^2=8.128, df=3, p<.05) confirms that respondents with a secondary grade average equivalent to B to a higher extent endorse the belief that mathematical ability remains relatively fixed throughout one's life.

Results on the mathematics item

There are gender differences in the responses on the mathematics item. The statistical chi-square test (χ^2=12.874, df=3, p<.01) suggests that female future teachers were more inclined to select the standard formula (an impossible strategy) or the strategy with counting unit squares (the appropriate one) as the strategy that grade 5 pupils are expected to use for finding the area of the given triangle, while the male teachers opted more for Pythagoras's Theorem followed by Heron's formula or for the distance formula with Heron's formula.

Language of studies also appeares to be a differentiating factor. The statistical chi-square test (χ^2=23.378, df=6, p<.01) suggests that future teachers studying in Macedonian language are more inclined to choose the strategy with counting unit squares, and less inclined to opt for Pythagoras's Theorem followed by Heron's formula; while the opposite proved to be true for the future teachers studying in Albanian language. The future teachers studying in Turkish language preferred the standard formula.

Future teachers studying different study programs differed in their responses on the mathematics item. The statistical chi-square test (χ^2=19.310, df=6, p<.01) suggests that future primary school teachers were more predisposed to choosing the standard formula or Pythagoras's Theorem followed by Heron's formula, and less likely to choose the

distance formula together with Heron's formula. Future pre-school teachers show inverse preferences.

Parents' education levels also influenced future teachers' responses on the mathematics item. The statistical chi-square test (χ^2=14.067, df=6, p<.05) suggests that respondents whose mothers have completed university education were more predisposed to choosing the appropriate strategy (counting squares) or Pythagoras's Theorem with Heron's formula, and less inclined to selecting the standard formula or the distance formula with Heron's formula. The inverse preferences were common for respondents whose mothers have completed only basic education. Respondents whose mothers have completed secondary education were more inclined to select the standard formula or Pythagoras's Theorem with Heron's formula. Fathers' education levels were not related with the responses on the mathematics item.

No correlations were found between the responses on the mathematics item and neither the respondents' secondary education type nor their secondary grades average.

DISCUSSION AND CONCLUSIONS

The research findings reported in the paper have limitations such as: the sample of respondents is not representative, only one mathematics item is included in the survey, results from Likert-type scales have well-known limitations when such instruments are used for measuring beliefs isolated from knowledge or from instructional practices (Phillip, 2007). Although the results cannot be generalized, they provide indicators for further research of the beliefs of prospective primary and pre-school teachers. The findings suggest that gender, language of studies, type of teacher education study program, parents' education levels, as well as respondents' secondary education may play a role in certain aspects of future teachers' beliefs about mathematics, learning mathematics and mathematics achievement.

Gender played a role in the level of endorsement of only one of the statements about the nature of mathematics. Male respondents to a higher degree supported a belief related to the view of mathematics as a set of rules and procedures (reliance on knowledge of the exact procedure when solving a problem). Language of studies proved to differentiate more among the levels of endorsement of statements about the calculational or the conceptual view of mathematics. Future teachers enrolled in teacher education programs in Turkish language of study to a higher degree supported the view of mathematics as a set of rules and procedures (remembering, practice, correct application of routines). Although future

teachers studying in Macedonian language of study to a lesser degree endorsed one statement reflecting the calculation view (reliance on knowing the exact procedure when solving a problem), they also showed lesser endorsement of one statement related to the conceptual view of mathematics (engaging in mathematical tasks can lead to a discovery of new connections, rules, concepts). Lower education levels of mothers was related to future teachers expressing higher support of one statement related to the calculational view (reliance on the knowledge of the exact procedure), and lower education levels of fathers was related to a higher degree of endorsement of one statement reflecting the conceptual view (new things can be discovered when engaged in doing mathematics). Neither the type of teacher education study program, nor the secondary education of future teachers (type and grade average) proved related to the level of endorsement of the various beliefs about the nature of mathematics.

Support of beliefs about learning mathematics was not proven to be correlated to respondents' gender, type of teacher education program or parents' education levels. Language of studies was. Future teachers studying in Macedonian language showed lesser support for the direct transmission view of learning mathematics. To a lesser degree than their colleagues in Albanian or in Turkish language of studies, they endorsed statements referring to mathematics proficiency as an ability to solve mathematical tasks quickly and to assigning higher importance of getting the correct answer over the process of solving the problem. Future teachers in Albanian language of studies to a lower extent emphasized the importance of understanding the validity of a solution, and future teachers in Turkish language of studies to a higher degree expressed the belief that non-standard solution strategies of pupils could interfere with their learning of the correct ones. At the same time, future teachers in Turkish language of studies also supported the view of learning mathematics through active involvement by higher endorsement of the belief that investigation of the validity of a solution is a good time investment, and of the belief that discussion of different solution strategies is helpful for pupils. Vocational secondary education predisposed future teachers to express higher support for the direct transmission view of learning (pupils learn best by carefully attending teachers' explanations), and so did lower secondary grades average (hands-on mathematical activities are not effective).

Higher endorsement of the view of mathematics as fixed ability was proven to be related to gender, language of studies, parents' education levels, and secondary grades average. Male teachers to a higher extent expressed the belief that boys tend to be better than girls, and the belief

that older pupils receive less benefits from hands-on activities and visual aids since they could reason abstractly. Future teachers in Macedonian study language expressed lower endorsement on most of the statements reflecting the view of mathematics as a set ability. Future teachers in Turkish study language expressed higher support for the belief that mathematics is a male dominated domain, and future teachers in Albanian study language to a higher degree than their colleagues endorsed the belief that some people are good at mathematics, and some aren't. Analysis of the results also showed that lower education levels of future teachers' mothers are connected with higher endorsement of the view of mathematics as a set ability. The type of teacher education program and the type of secondary education of future teachers was not proven to be related to the levels of endorsement of the view of mathematics as a set ability. Phillip (2007) summarized that a number of research studies provided evidence that teachers stereotyped mathematics as a male domain, and that teachers' beliefs affected pupils' beliefs in promoting the same stereotypes. Therefore, these findings indicate that a carefully designed approach in work with future teachers is necessary in breaking this cycle, and that teacher educators might benefit from getting a more precise picture of the beliefs that future teachers hold.

Gender, language of studies, study program and mothers' education levels proved to influence future teachers' responses on the mathematics item.

Existing literature (Blцmeke & Delaney, 2012; Phillip, 2007) indicates that the interpretation of these findings requires viewing them as components of a complex system of knowledge (in particular, mathematics content knowledge and mathematics pedagogy content knowledge) and of professional beliefs. Further investigation of future teachers' beliefs (and knowledge) has to be carried out in order to establish the stability of these connections. Only then, informed decisions on how to plan and implement mathematics and mathematics methods courses for primary school teachers and pre-school teachers can be made.

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