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Developing and Piloting an Instrument for Measuring Upper Secondary Mathematics Teachers Beliefs in Nitra Region

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Abstract

In our contribution we present the design and piloting process of instrument for measuring mathematics teachers' educational beliefs in Slovak educational settings. We briefly describe the theoretical framework on which the presented questionnaire is based. We also present the preliminary results of data collected from upper secondary mathematics teachers in Nitra region and the process of factor developing. For data analysis and reduction of items we used principal component analysis. Than we correlate the obtained factors to see the modules consistency. We present the particular parts of the questionnaire and some preliminary results of three selected modules of the questionnaire.

Keywords: Teachers' beliefs, PCA, in-service teachers.

Classification: C19,C29

Introduction

Investigation of mathematics teachers' beliefs is one of the international research interests in mathematics education. This focus is mostly influenced by the mathematics educational reform that oriented mathematics education more to student-centered education and problem solving on national level. Within these settings there have been new demands on mathematics teacher as one of the key factors of successful educational reform. Important, mostly labeled as "hidden", variable in this educational transformation are beliefs, because they reflect in what way mathematics and its teaching and learning is conceptualised by teachers. Thompson states that „what a teacher considers to be desirable goals of the mathematics program, his or her own role in teaching, the students' role, appropriate classroom activities, desirable instructional approaches and emphases, legitimate mathematical procedures, and acceptable outcomes of instruction are all part of the teacher's conceptions of mathematics teaching" (Thompson, 1992, p.135 in Lepik, Pipere 2012).

In comparison with the international research there is still lack of empirical data mapping and analyzing mathematics teachers' beliefs structure within the Slovak educational settings. In our contribution we aim to describe the theoretical background and pilot the instrument in Slovak educational settings. The instrument was prepared in international collaboration

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for measuring of aspects of upper secondary mathematics teachers' beliefs concerning job satisfaction, teaching, school mathematics and mathematics didactics.

Theoretical framework

In our contribution we understand teachers' beliefs broadly as "conceptions, view and personal ideologies that shape teaching practice" (Lepik, Pipere & Hannula 2012). It is assumed that what one beliefs to be right influences what one does – beliefs act as the teacher's pedagogical predispositions. Thus, we consider beliefs as factors shaping the teacher's decisions, for example, about what goals should be accomplished and how should the effective learning of mathematics look like (Schoenfeld, 1998 in Hannula & al. 2013). We understand beliefs as regulating system closely connected with teachers everyday practice that influences instant decisions they need to make every lesson. Based on the research, we can assume that there are several time periods when and how the mathematics teachers' beliefs are developed. There is a suggestion that teachers start their careers with previously constructed and possibly subconscious theories about teaching (Powell, 1992 in Lepik, Pipere & Hannula 2012). The important time when beliefs development may be influenced is the period during the teacher preparation. As (Šunderlík, 2010) suggested, during teacher preparation also the teacher's identity is developed. Within this process the implicitly held beliefs, from own school years at secondary school, may be questioned during the teacher preparation, especially during their student teaching. Supporting pre-service teachers' reflection skills enables prospective teachers to enact their own implicitly held beliefs in their teaching. Furthermore, as Clarke (1988 in Lepik, Pipere & Hannula 2012) suggests, teachers continue to hold their implicit theories throughout their careers. In our study we are interested in mapping this stable experienced mathematics teachers' beliefs system. Considering the inner character of the beliefs system, we understand that it is hard to make a direct insight into this system. That is why we narrow our target to the teachers' openly acknowledged explicit or espoused beliefs (what is said) designating what teachers think about the impact of teaching in general, as well as their understanding of how children learn, being aware of the potential inconsistency between the espoused beliefs, less conscious implicit beliefs, and beliefs in action or enacted beliefs demonstrated in the consistent behavior (McMullen in Lepik, Pipere & Hannula, 2012).

Based on the research, we measure the level of two major constructs of general and mathematics teachers' beliefs about the nature of teaching and learning. Within the general beliefs about good teaching and learning we include "direct transmission beliefs about learning and instruction" or so called, "traditional beliefs" and "constructivist believes about learning and instruction" (OECD, 2009). However, recently some voices have appeared, challenging any dichotomisation in educational studies, and especially in international comparative research, , suggesting the complementary view on the interrelated nature on teacher-centred vs student-centred classrooms. (Andrews & Sayers, 2013; Clarke, 2006 in Lepik, Pipere & Hannula, 2012). Within the mathematics teachers' beliefs we consider three mathematical constructs that are described in Rösken & Liljedahl (2006). These constructs can be briefly characterized as follows: "Pupils should have an opportunity to independently develop their mathematical understanding and knowledge" (Process), "In a mathematics lesson, there should be more emphasis on the practicing phase than on the introductory and explanatory phase" (Toolbox); "Working with exact proof forms is an essential objective of mathematics teaching" (Proofs).

Research focus

In our contribution we pilot the instrument for measuring mathematical teacher beliefs about good effective teaching of upper secondary mathematics teachers. For this purpose it is necessary to verify how the theoretical construct of general teacher beliefs and mathematics beliefs about good teaching works within the Slovak educational settings.

Methodology

For data collection we used questionnaire that was developed to be valid in cross-cultural way to measure different aspects of teachers' mathematics-related beliefs. The questionnaire was based on the NorBa project questionnaire prepared for lower secondary mathematics teachers (Lepik & Pipere, 2012). This tool was adapted for upper secondary mathematics teachers. Some questions were deleted, new items about using ICT and new module F focused on views about mathematics was added. The modules of the final version of the questionnaire describe A) general information; B) teachers' overall job satisfaction; C) views of two teaching approaches; D) views about good teaching; E) teachers' conceptions of good teaching/learning of mathematics; F) views about mathematics; G) and questions about typical classroom practices. Different modules give us a unique opportunity to set up separate factors for each area of interest, and then compare them within the modules to the obtained complex view about teachers' mathematical beliefs structure. In our contribution we focus on analysis of modules C, D and E.

Module C consists of two descriptions of mathematics teaching that is focused on teaching combinatorics. The first teacher represents mostly the traditional way of teaching, whereas the second teacher represents mostly the constructivist way of teaching. After these two situations, there are four questions asking teachers which of the two teachers they prefer. Module D is focused on teachers' general beliefs on teaching and learning. It consists of 23 Likert-type items. The module E measures teachers' beliefs on mathematics teaching and learning. It contains 20 Likert items from (Pehkonen and Lepmann, 1994 in Hannula, Lepik, Pipere, Tuohilampi, 2013). The items are focused on three different constructs (see above): system, toolbox and process. The questionnaire was prepared in English and then translated into Slovak. The translation was performed simultaneously by two translators and checked by a math educator fluent in English and an external translator who also did the qualified Slovak proof-reading to ensure the best possible translation of all items.

Participants

Data were collected from the upper secondary mathematics teachers in Nitra region (n = 56). The age of this teachers ranged from 31 to 65 (average = 50); the length of service of these teachers ranged from 7 to 44 (average = 26). Within this group there were 33.9% teachers from grammar schools and 66.1% teachers from vocational schools. Their average age was 50 years; 25% of them were male; 35.7% of them were qualified Doctors of Pedagogy; all of them were qualified mathematics teachers; and 34% of them had attended less than 5 days of Professional development. The average number of students in a classroom was 25.

The data collection was completed in February, 2015, in Nitra region. Data collection was realized in cooperation with the regional school authority. Data were collected via online questionnaire that was sent to official school address and was forwarded to mathematics teachers. Collected sample is about 34% of the entire population of upper secondary mathematics teachers. We can assume that our sample is representative because if we compare our sample with the entire population of upper secondary teachers in Nitra region based on survey of Ministry of Education in school year 2014/2015 the median of teaching experience in our sample is 27 years, median of teaching practice of all teachers is 22 years, percentage of women in our sample are 74% within all teachers there are 77% of women and in our sample 33% of teachers teach at grammar school and in entire population there are 37% of teachers teaching at grammar school.

Analysis

In order to reduce data into fewer, but more reliable variables, we used principle component analysis. Modules D and E were analyzed separately with the use of Varimax rotation. The common statistical criteria for PCA were tested that can be find in (Leech, Barret, & Morgan, 2008). Several variables in modul D had to be removed due to low communality or multiple loadings. For clearer picture several solutions with different numbers of factors were tested. The criteria to select the factors were reliability and easy interpretation of the factor.

Results

Upper secondary mathematics teachers' background.

Module C

In module C teachers are asked to read about two approaches of teaching combinatorics. Teacher A used mostly transmisive way of teaching and teacher B used constructivist way of teaching. After that teachers are asked to answer four questions presented in Table 1.

Table 1*:*

Questions related to specific learning goals	**Average response (mean±STD)**	**Definitely A Tend toward A (%)**	**Cannot decide (%)**	**Definitely B Tend toward B (%)**
C1 Which type of class discussion you would be more comfortable having in class?	3.87 (1.11)	20%	7%	73%
C2 Which type of discussion do you think most students prefer to have?	3.58 (1.18)	24%	16%	60%
C3 From which type of class discussion do you think students gain more knowledge?	4.09 (1.06)	15%	2%	83%
C4 From which type of discussion do you think students gain more useful skills?	4.16 (0.98)	11%	7%	82%

In the first question we asked directly about the teaching style teachers prefer; in questions C2 – C4 we asked indirectly about teachers' belifs asking about what they thinks about the influence of two approaches of instruction to students learning. As evidenced by the results of module C, upper secondary mathematics teachers in Nitra region prefer teaching style of teacher B, who represents the more constructivist way of teaching. This pattern is slightly shifted only in question 2 asking for type of discussion students prefer. This is something interesting because constructivist instructions are based on more open student-centered questioning. This inconsistency in pattern is open to several possible explanations. It may be culturally based that students are not used to discussion about mathematics and teachers consider it as if students preferred direct "traditional" question with clear answers. We can suggest that teachers tend to simplify the questions until they get the desired answer. It may be also the case of how long the teachers are willing to wait for a discussion or a complex answer. To answer this question a more accurate and detailed qualitative research need to be conducted. Based on module C results, we assume that about ¾ of upper secondary mathematics teachers prefer constructivist way of mathematics instruction. Quite high percentage can be expected also because reform national curriculum preferer more constructivist way of instructions.

Module D

In module D the 23 questionnaire items were subject to the principal component analysis (PCA) with Varimax rotation. The number of extracted factors was determined by using classical eigenvalues and scree diagrams. Based on these criteria, it was decided to explore solutions of four, three and two factors. The best solution with most obviously interpretable factors was found in two-component structure. This corresponds with (Lepik, Pipere & Hannula, 2012) and also with the above mentioned theoretical framework that reduces the questions in module D to two major factors. Because of low percentage of explained total variance we reduced the number of items and used the same model with thirteen items. The removed questions will be analyzed and reformulated. This two-component solution explained a total of 41.2 % of the variance. The first factor F_D1 was labelled Reasoning and conceptual understanding we labeled it as (constructivist) ($\alpha = .765$). Eight items forming this factor represent a perspective on (mathematics) teaching which emphasizes the students' active and meaningful participation in learning process: students' discoveries and inquiry on problems, working in small groups; aiming at conceptual understanding. The second factor F_D2 was labelled Mastery of skills and facts (traditional) ($\alpha = 0{,}655$). The five items of this factor emphasize (mathematics) teaching as concerned with the formal teaching of skills and fluency through practice of routine procedures; repeating the basic skills; there should be exact instructions to students; during teaching there should be silence in the classroom and foremost the direct transmission of knowledge from the teacher to the pupil. The reliability level of this factor is not so high. This may be because of lower number of items in the factor. In general, this construct remained stable throughout all tested factor-models. Although the reliability of this factor was not very high, we believe that it is a well-defined construct and it can be used for reducing data complexity. Both factors F_D1 and F_D2 seem to be independent components and not opposite extremes of one scale. So, in case of an individual teacher they both may exist in parallel. For example, a teacher who emphasizes discoveries and inquiry on problems in their teaching may also highly value practicing of routine procedures.

Module E

In module E twenty items were subject to the PCA with Varimax rotation. The analysis was performed in the similar way as for module D. The number of extracted factors was determined by eigenvalues and scree diagrams. Based on these criteria, it was decided to explore solutions of four, three and two factors. The best solution was with three factors. In comparison with theoretical framework (Rösken & Liljedahl 2006). There is some overlap between factor system and toolbox within the Slovak upper secondary mathematics teachers. There were also one inconsistency between theoretical and empirical model of factors. Two items that were design to contribute to toolbox factor contribute to system factor. Althoug this small inconsistency we named the factors as system factor. If we look closer to few more toolbox and system items they contribute also to both factors. This results give us reason for later investigation of the relationship between this two factors between Slovak upper secondary teachers in larger sample. Based on the data we named these mathematics teaching beliefs: F_E1 System (α=0,817; 9 items), F_E2 Process (α=0,728; 6 items), F_E3 Toolbox (α=0,692; 5 items). The empirical factors were almost identical with the theoretical factors. The toolbox factor has again lower reliability level that may be caused by the lower number of items within this factor.

Comparison of factors construct

For each teacher we calculate the values of each factor in module D and E. Than we correlate this values to see the relationships between the calculated factors. Based on the three modules we would like to see whether the teacher answers correlate within the modules. We are especially interested in correlation between module D, E and question C2.

Table 2*: Pearson correlations between view of two teaching approaches, general teaching beliefs, and mathematics teaching beliefs.*

	F_D2	F_E1	F_E2	F_E3	C1	C2	C3	C4
F_D1 (constructivist)	0.00	0.12	0.49**	0.26	0.23	0.29*	0.11	0.08
F_D2 (traditional)		0.34*	-0.25	0.48**	-0.27	-0.40**	-0.46**	-0.42**
F_E1 (system)			0.00	0.00	0.01	-0.09	-0.23	-0.24
F_E2 (process)				0.00	0.26	0.24	0.33*	0.26
F_E3 (toolbox)					-0.07	-0.21	-0.19	-0.19
C1						0.48**	0.74**	0.67**
C2							0.49**	0.40**
C3								0.85**
*. Correlation is significant at the 0,05 level (2-tailed).								
**. Correlation is significant at the 0,01 level (2-tailed).								

In the correlation table we can see that constructivitist way of instruction and positive beliefs towards process oriented teaching mathematics were significantly correlated, $r = 0.49$, $p < 0.01$. Next, we can see that traditional way of instruction and positive beliefs tovards toolbox oriented teaching mathematics were significantly correlated, r = 0.48, p<0.01 and also towards system oriented teaching r = 0.34, p < 0.05. We can also see that the factor F_D2 correlates negatively with questions C2 r = -0.4, p < 0.01; C3 r = -0.46, p < 0.01 and C4 r = -0.42 p < 0.01. There is also a small correlation between F_E2 and question C3 and F_D1 and question C2 on α=0.05. In general, these preliminary results show us consistency of similar factors construct within the three presented modules.

Discusion and Conclusion

In our contribution we present the preliminary analysis of three modules of designed international instrument for measuring mathematics teachers beliefs in Slovak educational settings. Based od the PCA analysis we verify the theoretical constructs with empirical results of our data. Also the reliability of presented items within the modules gives us a positive signal of appropriate usage of designed istrument for measuring of espoused beliefs of upper secondary teachers. Based on the presented results we consider this questionnaire to be valid and suitable for further analysis and measuring of mathematics teacher beliefs. The pilot also has shown problematic formulation of several items that will be further analyzed and reformulated.

On the other hand, we need to be aware of inner aspects of beliefs, and that is why for more complex picture it would be beneficial to support the obtained data with observation of everyday practice of mathematics teachers where also contextual factors, teacher knowledge transferred to teachers' competence and school culture can be considered.

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