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The Development of Didactic Competence of Pre-service Mathematics Teachers Through Teaching Practice at School

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Abstract

The article investigates the development of teaching profession competence of the students at the Lithuanian University of Educational Sciences during their teaching practicum at school. The research focuses on how pre-service mathematics teachers develop their own original teaching methodology. The main research question addressed in this study is: are teaching and learning methods chosen by the two groups of students, who studied by different programmes (former or new), linked more to the traditional methodology based on the normative educational paradigm or to the innovative methodology based on the interpretive paradigm? The objective of the study is twofold: to highlight the features of developing pre-service teachers' didactic competence in using mathematics teaching methods, and to investigate the relationship between the teaching practicum model and teaching methodology developed by pre-service mathematics teachers. The results reveal that the majority of the pre-service mathematics teachers, who studied by the former study programme, frequently used traditional teaching and learning methods. The pre-service mathematics teachers, who studied by the new study programme, more often utilise both teacher-oriented and student-centered instruction methods, so that the new teaching practicum model is more effective for the development of their didactic competence.

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Keywords: Didactic competence, mathematics, pre-service teacher, teaching practicum.

1. Introduction

1.1. Mathematics teachers' education and teaching quality

Since the beginning of the 21st century, mathematics survey results on the national level have demonstrated a decline in learners' achievements (Nacionalinis egzaminų centras, 2012; Nacionalinis

egzaminų centras, 2013; Nacionalinis egzaminų centras, 2014). A similar situation can be observed in other European countries: “Low student achievement in the basic skills of literacy/mother tongue, mathematics and science is a concern for many European countries” (European Commission, 2015a, p. 23). At the same time, the interest to study natural sciences and mathematics is decreasing all around Europe (European Commission, 2011; European Commission, 2012).

Researchers suggest that “the nature of mathematics teaching significantly affects the nature and outcomes of student learning” (Anthony & Walshaw, 2009, p. 27), and “the quality of education can never exceed the quality of teaching and teachers” (Schleicher, 2016, p. 10). A number of educational researches conducted over the last decade show “a link between the quality of teaching and teacher education on the one hand and student attainment on the other” (European Commission, 2011, p. 113). Moreover, the European Council report emphasizes the importance of teacher education: “Effective teaching depends to a large extent on the expertise of teachers; consequently their knowledge of the subject and their professional training are crucial” (European Commission, 2015a, p. 30). That is one of the main reasons why European countries are encouraged to “promote the development of comprehensive professional competence frameworks for teachers, which define the competences and qualities they require ... in different teaching situations” (Council Conclusions of 20 May 2014 on Effective Teacher Education, 2014, p. 4).

The European Commission highlights that “there is also a trend towards increasing the amount of practical training, including school-based practice, within programmes” (Strengthening Teaching in Europe, 2015, p. 2). Practical training may involve “observation of classroom activity, as well as sole or shared responsibility for the conduct of some lessons under the guidance of an experienced teacher” (European Commission, 2015b, p. 39). The shift to the practice-based education is grounded on the results of a number of educational researches that indicate the importance of practical training of pre-service teachers seeking to provide them with better support to learn quality teaching (Anthony, Hunter & Hunter, 2015; Ball, Ben-Peretz & Cohen, 2014; Forzani, 2014; Grossman, Hammerness & McDonald, 2009; Lampert, 2010; McDonald, Kazemi & Kavanagh, 2013; Zeichner, 2012).

1.2 Initial education of mathematics teachers at Lithuanian University of Educational Sciences

In Initial Teacher Education (ITE) the Bachelor’s degree (ISCED 6) is required to work in the field of general education in Lithuania. Lithuanian University of Educational Sciences (LEU) is the biggest teacher training institution of our state. It provides the ‘concurrent’ model of ITE: pre-service teachers start learning the profession from very beginning of their studies; apart from subject knowledge, they acquire professional skills as a teachers of mathematics. The duration of the professional training is 60 ECTS credits (in full-time studies). It includes theoretical studies (theory of teaching, psychology, subject teaching methodology, etc.) and teaching practicum at school (in-school placement). The scope of in-school placement has been 30 ECTS credits since 2010, when a new initial mathematics teacher training programme was implemented.

The studies for pre-service teachers of mathematics, who assumed their studies before 2010, were organised following the study programme that contained only one independent teaching practicum at school (12 ECTS). Entrants to the new programme of mathematics education (since 2010) attend a

four-stage in-school teaching practicum: observation practicum (3 ECTS), teachers assistant's practicum (6 ECTS), teaching practicum under mentor's supervision (9 ECTS), and independent teaching practicum (12 ECTS) (Pedagoginių praktikų reglamentas, 2013). All the four stages of the teaching practicum are supervised by a school teacher of mathematics with regular assessment given by the teacher-mentor at school. In-school placement is administered by the university. The teacher of mathematics didactics is the coordinator of the teaching practicum, who manages and supervises pre-service teachers' practical training at school, as well as assesses their tasks/portfolios and reports.

1.3 Research problem and objectives

It is assumed that the changes in the study programme with the extended teaching practicum has an effect on the teaching competence of the pre-service teachers of mathematics. Hence, the following problem statement is posed as a question: is the new model of teaching practicum more efficient for the development of teaching competence or not, and how does the change in it affect the change in pre-service teachers' didactic competence?

The rationale underlying this research is finding the way to improve the professional development of pre-service mathematics teachers so that they develop their didactic competence through teaching practicum at school. The opportunities for a successful development of the didactic competence of pre-service teachers are revealed through the investigation of the changes in the practicum model, as well as the repertoire of teaching techniques and mediums. The research focuses on how pre-service teachers create their own original mathematics teaching methodology. The main research question addressed in this study is: are teaching and learning methods chosen by the two groups of students (who studied by different programmes) linked more to the traditional methodology based on the normative educational paradigm (teacher-centered instruction) or to the innovative methodology based on the interpretive paradigm (student-centered instruction)?

The objective of the study is twofold: to highlight the features of developing pre-service teachers' didactic competence in using teaching methods of mathematics, and to investigate the relationship between the teaching practicum model and teaching methodology developed by pre-service mathematics teachers.

2. Theoretical background

2.1 Professional competence of the teacher

According to the survey on European teacher education, the inclusion of the three key components into ITE – content, theory of teaching and practice – “is very important for teachers to be fully equipped to do their job” (European Commission, 2015a, p. 10). They are defined as follows: content is “sound academic knowledge of the subject(s) to be taught”; theory of teaching (pedagogy) consists of theoretical knowledge and initial teaching skills that pre-service teachers “need to be theoretically prepared to teach their subject, support pupils in learning, and manage classes” (European Commission, 2015a, p. 32); whereas practice gives the experience that enables pre-service teachers “to become adept at handling everyday issues in teaching and to manage classes in a wide variety of situations” (European Commission, 2015a, p. 39).

Lithuanian teacher training is based on a number of key documents drawn up by the Ministry of Education and Science. Teacher's Profession Competence Inventory (Mokytojo profesijos kompetencijų aprašas, 2007) is one of them. As it is noted in this document, teacher's profession competence includes intercultural, general and special professional competencies. The teacher's teaching competences is composed of the following competencies: planning for delivery of course content; managing of the teaching/learning process; creating and maintaining an effective educational environment and using information technologies; students' cognition and recognition of their progress; evaluation of students' achievement and progress; students' motivation and support; pursuing for professional development. These competencies are basically developed through the studies of general didactics, subject didactics and teaching practicum at school.

2.2 Didactic competence

Although the research base for effective development of teachers' pedagogical competence is limited, it may be noted that researchers have worked on the concept of teachers' didactic competence as a substantial element of pedagogical competence. The following categories of pedagogical competence can be distinguished on the basis of scientific studies on pedagogical competence in Lithuania: pedagogical-psychological, methodological or didactic, organisational, information technology, personal, and others. The didactic competence is recognised as the most important component of the teaching competence (Adomaitienė & Teresevičienė, 2001; Čiužas & Šiaučiukėnienė, 2007; Čiužas, 2013; Lamanaukas, 2002; Rodzevičiūtė, 2006; Rodzevičiūtė, 2010).

R. Čiužas (2013) argues that educational studies focus on teachers' didactic competence by exploring their educational activity through separate elements of the educational system and by attributing them to particular characteristics, for example, goals, content and methods of teaching and learning, as well as motivation and assessment of students' achievements. Thus, didactic competence consists of teacher knowledge of a variety of teaching strategies and methods, as well as the ability to apply them in the teaching process. Since pedagogical competence is defined as a system of knowledge, abilities and skills, attitudes and values determining effective education (Mokytojo profesijos kompetencijų aprašas, 2007), didactic competence may be defined as the possession of didactic knowledge, teaching skills and professionally significant personal values that are essential necessary for quality subject teaching.

The investigation of mathematics teacher education and teaching quality is very often grounded on the concept of pedagogical knowledge, which was created by L. Shulman at the end of the last century (Shulman, 1986, 1987). In general, proponents of the concept analyse two structural parts of pedagogical knowledge: subject knowledge and pedagogical content knowledge (Cochran, DeRuiter, & King, 1993; Grossman, Hammerness, & McDonald, 2009; Marks, 1990; Schoenfeld, 2016; Van Driel & Berry, 2010). Within this approach, didactic competence is an integral component of pedagogical content knowledge, which is defined as a "complex interplay between knowledge of subject matter, teaching and learning, and context, and the way in which teachers combine and use this knowledge to express their expertise" (Van Driel & Berry, 2010, p. 659).

The analysis of the content of didactic competence is based on the terms, which describe pedagogical content knowledge and reveal a lot of similar characteristics. For example, both of them include knowledge of how to design learning objectives; how to design the teaching content; how to organise didactic activities in accordance with the dominant lesson type; how to use teaching methods and strategies closely related to the individual/group particularities and educational goals; as well as how to plan and evaluate a lesson.

2.3 Investigation of didactic competence components

Previous educational research on teaching competence of pre-service mathematics teachers has shown that the development of the teaching methodology employed by pre-service teachers is mainly determined by the changes in their competence to plan for delivery of course content and to manage the teaching/learning process (Cibulskaitė, 2012). This study focuses on the following components: an ability to choose and apply the most suitable methods for the teaching process with regard to educational objectives; an ability to use modern educational technologies for understandable conveying of educational information; an ability to choose different teaching strategies that can foster students' critical thinking, as well as problem-solving skills and creativity (Mokytojo profesijos kompetencijų aprašas, 2007).

Pre-service teachers can develop these initial abilities designing lesson plans for the classes of mathematics didactics. Teaching practicums provide opportunities for pre-service teachers to increase their understanding of the practical application of theoretical knowledge of didactics, and give the experience of the implementation of the drawn-up lesson plans. Researchers argue that “when professional development is school-based and embedded in the daily work of teachers, learning is more likely to occur” (Knight et al., 2015, p. 301). The coherence of theoretical studies and practical implementation of knowledge that has been acquired allows pre-service teachers to effectively foster their didactic competence (Cibulskaitė, 2012).

Educators note that students' learning objectives is the starting point for lesson planning, which can be defined as the process of preparing a framework for teacher activity in the classroom (Gage & Berliner, 1994; Panasuk & Todd, 2005). Teachers' effective performance in the classroom “involves the preconceived planning of a lesson beginning with the formulation of education aim and lesson's objective, and finishing with the envisaging of results and managing the education process during a lesson” (Čiužas, 2013, p. 36). Lesson planning includes “teachers' purposeful efforts in developing a coherent system of activities that facilitates the evolution of students' cognitive structures” (Panasuk & Todd, 2005, p. 215). Thus, a lesson plan can be regarded as a teacher's original didactic means, which provides a sequence of the educational process, teaching aids and conditions.

2.4 Knowledge of lesson planning

From the technical standpoint, pre-service teachers should be introduced to a lesson plan format. The format recommended by the educators of our university is used to develop lesson planning skills of pre-service mathematics teachers in the classes of mathematics didactics (Pečiuliauskienė & Barkauskaitė, 2011; Cibulskaitė, 2014b). In general, a lesson plan consists of two parts: general

information (school, grade, teacher, topic, objectives, methods used, textbook and other resources, type of assessment, tools and techniques) and minutes (description of the process: stages of a lesson stages and their length, developmental activities, instruction guide).

The lesson planning model used in our didactics classes is similar to the strategies offered by Panasuk, Stone & Todd's (2002) in their Four Stages of Lesson Planning (FSLP) (objectives; homework; developmental activities; mental mathematics) with the difference in planning of the delivered content units/thesaurus (objectives – expected outcomes – assessment; teaching content units – homework; developmental activities – content, instructional approach, teaching/learning strategies, methods, mediums, techniques; motivation – mental mathematics). This sequence is suggested for planning as well as FSLP strategy, but the procedure of a lesson progresses from the following stages: setting an objectives, motivating through mental mathematics or posing a problem for inquiry, review, developmental activities, setting homework, and summarising that includes students' self-assessment.

From the didactical point of view, the content of a lesson plan depends on one of the alternative paradigmatic approaches supported by a teacher: normative (traditional, classical, industrial) or interpretive (humanistic, free education, post-industrial). The separator axis is the relation “with the person's nature, being in cooperation with it or operating it” (Bruzgelevičienė, 2014, p. 498). Following this concept, a teacher can act by emphasising the transmission of knowledge or organising active and responsible learning of students.

2.5 Competence in planning for delivery of course content

The science of educational has accumulated a lot of knowledge about what is an effective mathematics teaching. A number of researches on teaching and learning has provided a variety of teaching methods and techniques that may be used by teachers in order to improve their classroom performance and student learning (Darling-Hammond, 2008; Gage, 2010; Good & Brophy, 2014; Grouws & McNaught, 2008; Hatch, 2005; Hiebert & Grouws, 2009; Higgins et al., 2015; Kauchak & Eggen, 2006; Marzano, 2007; Shulman, 2004; Slavin, 2011; etc.). However, no research provides an unambiguous and universal recommendation on how to arrange a quality mathematics lesson. On the contrary, there are many different models or systems of principles for modern workable and innovative subject teaching and a quality lesson. These systems have been created by well-known educators and researchers, and widely used by teachers over the past decades, for example, *The Strategic Teacher* (Silver, 2007); *Principles of Effective Pedagogy of Mathematics* (Anthony & Walshaw, 2009); *Canadian Seven Foundational Principles for Improvement in Mathematics* (Paying Attention to Mathematics Education, 2010); *17 Principles of Effective Instruction* (Rosenshine, 2012) and others.

Anyway, educational researches, which summarise the teaching approaches and methods recommended or supported in different European countries, suggest that there are no best approaches to teaching mathematics, yet different strategies and methods can be effectively applied in a particular classroom: “teachers need to choose appropriate methods and strategies to suit the topic, the type of student and the particular learning context” (European Commission, 2011, p. 70). In general, every teacher creates an original methodology – an individual way to share the teaching/learning content with students in respect to students' characteristics and teachers' own self-expression (Cibulskaitė, 2014a).

In order for trainee teachers to be capable of selecting appropriate methods of teaching mathematics, it is important that they should have possibilities for the effective development of didactic competence in a range of different methods and especially their application.

2.6 Competence in teaching and learning process management

There are three common forms of teaching in educational practice: whole class instruction, managing of students' work in pairs and groups, and organisation of independent or individual work (Cibulskaitė, 2014b). The first is commonly based on the teacher-directed approach that involves mere teaching of mathematical facts, rules, concepts and procedures, presentation of a variety of examples, and guiding students during their practicum; others are grounded on the student-centered approach that presupposes students' engagement in active learning: communicating mathematical ideas, justification of solutions, and rich reflective practices with students having opportunities of self-correction and deep conceptual understanding (Blumberg, 2008; Echazarra et al., 2016; Schwerdt & Wuppermann, 2011). Meanwhile, the last teaching form emphasises students' independent learning by teacher support and guidance, which is recognised as a learner-responsive approach (Erchick et al., 2014).

The teacher-directed instruction is routinely used by teachers, who are mostly concerned with providing a well-structured and informative lecture. This instruction can involve summarising the previous lesson, establishing the goals of the current lesson, knowledge transfer, posing questions to students in order to make sure of their understanding, and inviting students to present their reasoning (Echazarra et al., 2016). The student-centered instruction aims at giving students a more active role: plan classroom activities, work in small groups, make joint solutions to a mathematical problem, perform projects or long-term homework, conduct self-evaluation, etc. (Blumberg, 2008; Deboer, 2002). In any case, "high-quality instruction is often defined as the use of a variety of classroom teaching practices, allowing for both teacher-directed and self-regulated learning" (Vieluf et al., 2012, p. 117). This demands such teaching approaches that go beyond teacher-directed and student-centered instruction: the first provides structure and clarity, and the second ensures supportive practices.

The literature on mathematics education reveals the importance of student-oriented practices, cognitive activation methods of instruction, and feedback for fostering conceptual understanding, profound knowledge, and students' motivation to learn (Baumert et al., 2010; Vieluf et al., 2012). Cognitive activation may be prompted by class discussion on cognitively challenging mathematical problems that allow students sharing the ways of problem-solving with the classmates; it may include students' reflection on the learning process, and require students to apply the gained knowledge in new contexts; effective formative-assessment instructional practices, such as checking homework, oral and written feedback on student work also include student reflection through self and peer assessment (Echazarra et al., 2016; Hattie, 2012; OECD, 2014; Vieluf et al., 2012). These methods can be used in whole class instruction, students' work in pairs and small groups, and especially in students' independent work.

3. Method

3.1 Participants

70 pre-service mathematics teachers of the final year of studies were involved in this study: 40 graduates of 2012, 2013 that studied by the former study programme including one independent teaching practicum at school, and 30 graduates of 2014, 2015, 2016 who studied by the new study programme including a four-stage in-school teaching practicum.

3.2 Research methods

The main data were collected through the qualitative and quantitative analysis of pre-service teachers' lesson plans and reports ($n = 70$); other information was gathered during the interview conducted by the university practicum coordinator ($n = 70$).

Each pre-service teacher delivered several topics during their practicum, and 10 lessons were assessed by their supervisor. During the interview conducted by the coordinator, the pre-service teachers were asked to select the best lesson plan according to the following criteria: the lesson was given the highest ranked by the supervisor because the objectives were implemented through an appropriate and reasonable choice of a variety of teaching methods; the teaching strategies and methods chosen by the pre-service teacher were suited to their own self-expression and thus, could give the basis for their authentic teaching methodology. The interview protocol was designed to probe the rationale for the selection of strategies and methods for each structural part of a lesson: the introduction, the main stage and the summarising.

Content and comparative analysis, as well as mathematical statistics methods were applied for data analysis. The quantitative analysis was performed using SPSS (Bekešienė, 2015): the percentage frequencies of the applied methods and Spearman correlation coefficients were calculated; Kolmogorov-Smirnov and Shapiro-Wilk tests of normality ($\alpha = .000$), and t-test for the significance of the difference between the means of two independent samples were completed.

4. Findings

4.1 The relationship between the teaching practicum model and teaching methodology created by pre-service mathematics teachers

The analysis of the lesson plans and interview protocols disclosed the methods, techniques and mediums which were used by the pre-service teachers at different stages of a lesson. The data frequencies (Table 1) showed that at the introductory stage:

- the whole class instruction form was preferred by both groups, they mostly applied teacher-oriented methodology: lesson objectives were arranged by the teacher (95%, 93.3%); a short summary of the previous lesson was presented by the teacher (57.5%, 63.3%) or through students' questioning (50%, 60%); homework assignments were checked orally and problems that posed challenges to students were solved on the blackboard (40%, 53.3%);
- students were motivated through the learner-centered instruction by providing real content and engaging problems (32.5%, 40%).

Two overlapping strategies selected by the pre-service teachers were consistent with the logic of the teaching process, since it was necessary to focus students' attention and engage them into learning at

the beginning of the lesson. Nevertheless, a lack of motivational activities was observed, while the students' curiosity could be raised by mathematical puzzles, elements of mathematics history (only two cases in Group I), and using a whiteboard; students could be engaged by the methods of collaborative work: a joint discussion of learning objectives, checking homework or creative tasks performed in groups.

It remains unclear why the pre-service teachers rarely checked students' individual homework, as mentors' homework policy was discussed in their practice reports and the ideas on how to improve feedback (that task was designed) were offered.

Although the percentages of the various methods used were often quite different, the statistical t-test analysis (Table 1) did not show a significant difference in the methodology applied by both groups at this stage of the lessons.

Table 1. Frequency of methods and techniques used by the two groups of pre-service mathematics teachers during the teaching practicum (%) and statistically significant differences in t-test

Lesson stage	Teaching form (work)	Teaching/learning methods, and techniques	Group		t-test
			I	II	p = .05
1. Introduction	Whole class	Motivational tasks	32.5	40.0	
		Announcement of lesson objectives	95.0	93.3	
		Announcement and discussion of lesson objectives	0	3.3	
		Checking homework and solving difficult tasks by the teacher on the blackboard	40.0	53.3	
		Checking homework and solving difficult tasks by a student on the blackboard	7.5	6.7	
		Review by the teacher	57.5	63.3	
	Review by a student and questioning of theoretical fundamentals	50.0	60.0		
	Collaborative	Checking homework in pairs or groups	5.0	10.0	
	Individual	Checking individual homework by the teacher	7.5	3.3	
2. The main stage	Whole class	Problem posing	5.0	10.0	
		Lecturing and heuristic conversation	87.5	86.7	
		Formulating of conclusions by a student	12.5	30.0	$\alpha = .009$
		Presentation of a variety of examples on the blackboard by the teacher	65.0	30.0	$\alpha = .037$
		Presentation of a variety of examples by using slides and the whiteboard by the teacher	22.5	40.0	
		The teacher's questioning to check students' understanding	52.5	80.0	$\alpha = .010$
		Students' practice: problem-solving on the blackboard, checking of solutions	62.5	36.7	$\alpha = .023$
	Collaborative	Students' practice: solving, discussing and checking in pairs and groups	27.5	53.3	$\alpha = .003$
		Students' advising of students	30.0	56.7	$\alpha = .009$
		Students' advising of the class	22.5	26.7	
The teachers' advising of groups		7.5	43.3	$\alpha = .000$	
Individual	Textbook analysis by students	5.0	20.0		
	Students' independent practice: solving and checking	90.0	100.0		
	The teachers' individual advising	82.5	73.3		
3. Summarising	Whole class	Homework announcement	92.5	100.0	
		The teacher's explanation how to do homework	12.5	33.3	$\alpha = .032$
		Summarising by the teacher	95.0	93.3	
	Collaborative	Students' assessment in pairs or groups	2.5	30.0	$\alpha = .001$
	Individual	Students' self-assessment (by using individual cards and signs)	30.0	63.3	$\alpha = .014$

At the main stage of the lessons:

- the whole class teaching form and individual work were mostly used, the methods of teacher-oriented and student-centered instruction were selected by both groups: students worked independently (90%, 100%) and were advised by the teachers (82.5%, 73.3%); lecturing and heuristic conversation (87.5%, 86.7%), presentation of examples on the blackboard (65%, 30%) and whiteboard (22.5%, 40%), active questioning (52.5%, 80%), and students' practicing on the blackboard (62.5%, 36.7%) were used;
- collaborative methods were rarely employed: students worked in pairs or small groups (27.5%, 53.3%) and were advised by each other (30%, 56.7%); groups were advised by the teacher (7.5%, 43.5%) and the whole class – by the student (22.5%, 26.7%);
- the following cognitive activation methods were used very rarely: asking students to draw the conclusions (12.5%, 30%), students' independent examination of the textbook (5%, 20%), and problem posing (5%, 10%).

The obtained data correspond to the results of Lithuanian and European studies in the methodology applied by in-service mathematics teachers, who state that lecturing, active questioning and students' individual practicing dominate in the repertoire of teachers' methods, whereas the methods of collaborative learning and new technologies are less frequently used (Cibulskaitė, 2014a; Echazarra et al., 2016; European Commission, 2011). These findings confirm the ones found by other researchers: the development of pre-service teachers' methodology is strongly influenced by their previous school experiences and mentors' methodology (Grossman et al., 2009; Rozelle & Wilson, 2012).

The following significant differences between the groups were identified by the t-test analysis:

- Group I used the blackboard for the presentation of examples and students' practice more frequently ($\alpha < .05$);
- Group II used active teaching practices, such as questioning, working in pairs or small groups and advising them, peer advising, and asking students to draw the conclusions more frequently ($\alpha < .01$).

The statistical analysis suggests that teaching/learning process was more frequently organised through the learner-centered strategy by Group II than by Group I. Thus, it is assumed that the new practicum model had a positive impact on the development of pre-service teachers' methodology. Anyway, the lack of using cognitive activation methods was observed.

Most practicum reports of this group indicated a positive belief of pre-service teachers in the opportunity to accomplish the four teaching practicum in different schools and to learn from various mentors, as it would allow testing different strategies and expanding the repertoire of methods and techniques.

At the summarising stage both groups:

- usually assigned homework (92.5%, 100%) and summed up the lesson (95%, 93.3%);
- less frequently organised the students' individual self-assessment (30%, 63.3%), explained how to do homework (12.5%, 33.3%), and organised students' self-assessment in pairs or groups (2.5%, 30%).

The t-test statistical analysis revealed the following significant differences:

- students' self-assessment ($\alpha < .05$) and pair or group assessment ($\alpha < .01$) were more frequently organised by Group II.

The results suggest that the methodology used by Group II at the last stage of a lesson was mainly based on student-centered instruction. The practicum reports and interviews indicated both groups having difficulty in combining lesson objectives and students' assessment: some of them claimed that the objectives were often formally announced and not suitably associated with students' assessment. Indeed, the analysis of the lesson plans revealed that students' achievements were almost never measured at the end of the lesson, just a few cases were identified when the pre-service teachers marked cumulative assessment scores for students' independent practice or group work. It is assumed that the competence of planning lesson objectives and their linking to with students' assessment is a relevant problem of training pre-service mathematics teachers.

4.2 The features of developing pre-service teachers' didactic competence in using mathematics teaching methods

The analysis using Spearman's correlation coefficient disclosed the features of developing pre-service teachers' didactic competence in using teaching methods. The following correlations between the applied methods, techniques and mediums in Group I were established (Table 2):

- the pre-service teachers, who presented a short summary of the previous lesson on their own or through student questioning, more often used active questioning and promoted student reflection but rarely provided motivational tasks;
- those, who used lecturing and heuristic conversation, more often presented examples on the blackboard but less frequently used new technologies, reviews, active questioning, homework explanation, asking students to draw conclusions and self-assessment in pairs or groups;
- those, who applied new technologies, more frequently used questioning, organised work and self-assessment in pairs or groups and advised them, explained how to do homework, and their students more often drew conclusions independently;
- pair or group work was positively related to teacher advising of students, students of students, and students of the whole class;
- students' practicing on the blackboard was positively related to student peer counseling and negatively to the practice in pairs or groups, using new technologies, provision of creative tasks, active questioning, and students' conclusion-making;
- teachers' presentation of examples on the blackboard was negatively associated with students' independent examination of the textbook and teachers' explanation how to do homework.

A smaller number of correlations was established in Group II (Table 3):

- the trainee teachers, who presented examples on the blackboard and gave motivational tasks, used new technologies more rarely;
- students' practice on the blackboard was negatively related to pair or group work and their advising by the teacher;

- students' conclusion-making was positively related to textbook examination and negatively to peer advising;
- students' work in pairs or groups was positively related to teachers' and peer advising, as well as self-assessment in groups;
- the trainee teachers, who explained how to do homework, more often used additional means.

The comparison of the findings with the frequency of different methods revealed that the majority of the pre-service teachers of Group I developed a more traditional teacher-centered methodology: they more often used lecturing and heuristic conversation, presented examples and asked students to solve problems on the blackboard. A small part of this group developed an innovative learner-centered methodology through collaborative methods and the use of new technologies. Although a relatively large part of Group II applied traditional methods (lecturing, review and homework checking, active questioning), a bigger part of this group, compared to Group I, used learner-centered methods and techniques (work in pairs or groups and their advising, individual and peer advising and assessment, asking students to draw conclusions, new technologies and additional means).

Table 2. Significant correlations between methods and techniques used by Group I (Spearman's rho and significance)*

Method / technique	TMot	TRev	SRev	TExpl	SCon	TBlb	TWhb	TQue	SBlb	SGr	SInAs
THw	-0.349 0.027										
TRev	-0.375 0.017		0.657 0.000	-0.325 0.041							
SCon				-0.314 0.048							
TBlb				0.357 0.024							
TWhb				-0.339 0.032	0.701 0.000						
TQue			0.451 0.004	-0.360 0.023	0.360 0.023		0.393 0.012				
SBlb					-0.332 0.036		-0.325 0.041	-0.323 0.042			
SGr					0.444 0.004		0.339 0.033		-0.332 0.036		0.452 0.003
TAdGr					0.466 0.002					0.462 0.003	
SAdS									0.507 0.001	0.696 0.000	
SAdCl										0.339 0.033	-0.419 0.007
STextb						-0.313 0.05					
THwEx		0.325 0.041		-0.543 0.000	0.543 0.000	-0.515 0.001	0.520 0.001	0.360 0.023			
SGrAs				-0.424	0.424						

	0.006	0.006			
SInAs	0.327				
	0.039				
Medi		0.655	0.318	-0.388	
		0.000	0.046	0.013	
CreatT				-0.398	0.525
				0.011	0.006

Table 3. Significant correlations between methods and techniques used by Group II (Spearman's rho and significance)*

Method / technique	TMot	TRev	SRev	SCon	TBlb	TWhb	SBlb	SGr	AdMea
SRev		0.508							
		0.004							
TWhbl	-0.389				-0.535				
	0.034				0.002				
SGr							-0.536		
							0.002		
TAdGr							-0.526	0.818	
							0.003	0.000	
SAdS				-0.455				0.800	
				0.012				0.000	
STextb				0.400					
				0.028					
THwEx									0.465
									0.010
SGrAs			-0.505					0.612	
			0.004					0.000	
Medi					-0.612	0.879			
					0.000	0.000			

***Explanation of abbreviations:**

TMot – Motivational tasks; **THw** – Checking homework and solving difficult tasks by the teacher on the blackboard;

TRev – Review by the teacher (presentation of a short summary of the previous lesson by the teacher);

SRev – Review by a student and questioning of theoretical fundamentals; **SConcl** – Formulating of conclusions by a student; **TBlb** – Presentation of a variety of examples on the blackboard by the teacher;

TWhb – Presentation of a variety of examples by using slides and the whiteboard by the teacher;

TQue – The teacher's questioning to check students' understanding;

SBlb – Students' practice: problem-solving on the blackboard, checking of solutions;

SGr – Students' practice: solving, discussing and checking in pairs and groups; **TAdGr** – The teachers' advising of groups;

SAdS – Students' advising of students; **SAdCl** – Students' advising of the class;

STextb – Textbook analysis by students; **THwEx** – The teacher's explanation how to do homework;

SGrAs – Students' assessment in pairs or groups; **SInAs** – Students' self-assessment;

Medi – Using of mediums; **CreatT** – The teachers' creative tasks; **AdMea** – The teachers' additional means.

5. Conclusions

The majority of the pre-service teachers, who studied by the former study programme (one practicum at school) frequently used traditional teaching and learning methods: lecturing and heuristic

conversation, presentation of examples and students' practicing on the blackboard, active questioning to check students' understanding; a smaller part of this group used innovative methodology, namely collaborative methods and new technologies.

A rather large part of the group of the pre-service teachers, who studied by the new study programme (four teaching practicums at school), used lecturing, review and checking homework assignments, as well as active questioning, yet in comparison with the first group of the pre-service teachers, a bigger part of this group used work in pairs or groups and their advising, individual and peer advising, individual and group assessment, asking students to draw conclusions, new technologies and additional means.

The methodology applied at the introductory stage of a lesson by both groups of the pre-service teachers was similar; however, the pre-service teachers, who studied by the new study programme, more frequently applied methodology based on student-centered instruction methods at the main and summarising stages of the lesson.

The teaching methodology developed by the pre-service teachers, who studied by the former study programme, was linked to teacher-oriented instruction, which was based on the normative educational paradigm. Meanwhile, the pre-service teachers, who studied by the new study programme, more often developed an innovative student-centered teaching methodology, which was based on the interpretive paradigm, so that the new teaching practicum model was more effective for the development of pre-service mathematics teachers' didactic competence.

The competence of planning lesson objectives and their linking to student assessment, as well as the competence of using cognitive activation, assessment and feedback methods are relevant problems of training pre-service mathematics teacher.

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