

The Relationship between Mathematics Teachers' Teaching Approaches and 9th Grade Students' Mathematics Self

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Abstract

The aim of the study is to investigate the relationship between the teaching approach adopted by mathematics teachers and their 9th grade students' mathematical self. The study searched for the answers on three research questions, namely, about 1) the approaches prevailing in mathematics teachers' beliefs about effective teaching and self-reports about their classroom practices, 2) the qualitative and quantitative features of students' mathematical self and 3) the relationships between the teaching approaches supported by mathematics teachers, the indicators of their 9th grade students' mathematical self, teachers' socio-demographic indicators, and students' socio-demographic indicators. The outcomes of the study show that because of the complex structure of the phenomena, it is difficult to classify mathematics teachers' beliefs on teaching and their self-reported practice into theoretically predefined groups though the use of constructivism in a lesson has a more positive influence on students' mathematical self than mere support of the constructivist beliefs.

Keywords: teaching approach, mathematics teaching, students' mathematical self, constructivism

Introduction

In the second decade of the 21st century, education in Latvia as well as in the world starts orienting towards principles of sustainable development. It is a reorientation towards other values, choosing quality instead of quantity, accepting and respecting diversity of people and their views, evaluating not only results, but also the processes during which these results have been achieved. Education is the sphere that is aimed at stimulating an individual's understanding of values and providing necessary knowledge and competencies. Education for sustainable development does not concentrate on providing knowledge, but rather on the search for possible solutions to everyday life situations which should definitely be reflected in curricula and teaching approaches. As education is changing, so is a teacher's and a student's role in it (UNECE, 2011).

Processes connected with education in scientific literature are characterised as complex, changing, non-linear, multidimensional, which is why education cannot be

viewed narrowly, merely within a context of school, apart from other processes in society because they are interconnected (Kuhn, 2008; Morrison, 2008). According to this view on education, learning is a process of development of an individual, a social group and a society, their mutual cooperation and constructive action, emphasising mutual interconnection and a view on an individual's mind as a complex adaptive system (Jess, Atencio & Thorburn, 2008; Morrison, 2008). Structural elements of the complex adaptive system intercorrelate in self-organised manner and the overall state of the system cannot be determined by the sum of its elements (Norman, 2011). These systems are based on the following principles: 1) system behaviour is unpredictable at the detail level, 2) small changes can result in major changes in system behaviour, 3) it is difficult to define the borders of the system (Holland, 1996; Norman, 2011; Waldrop, 1992). To design a conceptual framework of a teaching and learning process rooted in the holistic approach to education, it is vital to evaluate not only the structure of teaching and learning, but also the procedural aspects such as learner's interaction with the teacher and the content of learning (Badjanova & Iliško, 2015). The above mentioned principles should be taken into consideration implementing new approaches in education.

Implementation of new teaching approaches is a complex and quite unpredictable process. Hastily implemented reforms often cause confusion both in teachers, who are used to working in a definite way and have considered it as right and effective, and students, for whom the newly introduced things in teaching/learning process are unfamiliar and, frequently, they are used unprofessionally. Attention should be paid to the influence of social demographic indicators on mathematics teaching/learning process as well because several international researches reveal significant differences in such indicators as achievements and attitude towards mathematics when comparing them according to socio-demographic indicators (Ma & Kishor, 1997; Mubeen, Saeed & Arif, 2013). A more complete study of the problem from a teacher's point of view as well as exploring students' emotions, attitudes and perception would provide a deeper understanding about education process and help to both plan and implement a teaching/learning process that stimulates better results.

The mission of a teacher is its orientation to sustainability. Current frame of Anthropocene is un-sustainable that narrows and threatens the existence of mission driven pedagogy. The exclusion of mission driven pedagogy fosters poisoning of the society. Within the frames of Anthropocene, we need to renew pedagogy and the call for a teacher is to search for sustainability (Salite, 2015).

The following research questions were raised in the research process: (1) What kind of teaching approaches do prevail in 7th – 9th grade mathematics teachers' beliefs about effective teaching and self-report about their classroom practices? (2) What are qualitative and quantitative expressions of the indicators of the 9th grade students' mathematical self? (3) What kind of relationships exists among four aspects of the research: a) teaching approaches supported by mathematics teachers in their beliefs and actions in the classroom, b) their 9th grade students' mathematical self indicators, c) teachers' socio-demographic indicators, and d) 9th grade students' socio-demographic indicators?

Theoretical Framework of the Study

Variety of teaching approaches in the acquisition of mathematics

Teaching approach is defined as a dynamic correlation between the teacher's actions, intentions and beliefs (Pratt, 1992). This implies that the teaching approach includes the actual teachers' actions in the classroom which are based on their beliefs and intentions.

The teaching approach chosen by a teacher has a significant influence on the actual learning process, students' academic performance, knowledge and skills, their attitudes towards learning and the subject, the learners' beliefs about their skills as well as feelings and emotions in relation to the subject (Wentzel, 2002). Teaching approaches are also classified as student-centered, teacher-centered and content-centered (Hancock, Bray & Nason, 2003). According to Huitt (2006), teaching approaches can be divided into behavioural, cognitive, humanistic and constructivist. In the current research, the division into the traditional or a teacher-centered approach and the constructivist or a student-centered approach is used (Lord, 1999).

Constructivist ideas cannot be regarded as a modern innovation since they have been evolving in pedagogy since the 17th century (Fox, 2001). According to the objectivists' beliefs, on which the traditional teaching approach is based, knowledge reflects the real world, is fixed and is not associated with an individual (Jonassen, 1991). The constructivists' view of knowledge is the opposite: the human brain does not reflect the outside world but constructs an individual's experience and life representation through cognitive and emotional processes in the social context as a subjective idea and conceptions. According to the constructive teaching approach, the students are in the centre of teaching/learning process with all their preferences and needs, including emotional well-being, whereas the traditional teaching approach focuses on the teacher and the content while the affective factors are moved to the background. Therefore, it is assumed that the constructive teaching approach is likely to exert a more positive influence on students' emotional well-being during mathematics lessons as well as their attitudes towards mathematics and mathematicians.

Teachers' beliefs about mathematics teaching and their connection with action in the classroom

Beliefs help people to understand the meaning of life, the world and themselves. They influence the way how an individual perceives new information – adopting or rejecting it (Borg, 2001; Pajares, 1992). Since the beliefs are a broad concept, in terms of teachers' beliefs about mathematics teaching, they are classified into the definite groups:

1. beliefs on the nature of mathematics;
2. beliefs on the nature of mathematics teaching and learning;
3. beliefs on the ideal mathematics teaching/learning process (Ernest, 1989).

Theoretical overview of students' mathematical self

Mathematical self is a construct, which by its nature is between such constructs, previously mentioned and defined in scientific literature, as “mathematical identity” and “mathematical self-conception”. The mathematical self tries to integrate two notions

which are characteristics of mathematical self-conception – assessment of one's understanding of mathematics and becoming aware of one's achievement in the subject – with the attitude towards one's achievement in mathematics, the subject in general and its specialists, which, in its turn, is rooted in social constructivism and culture.

The author of the current research includes in the concept of students' mathematical self both quantitative indicators (mathematical self-conception, mathematical self-efficacy and mathematical anxiety) and qualitative indicators (perception of mathematics, mathematicians, a mathematics teacher and attitude towards them), which constitute a complementary view of mathematical self. All these concepts can be united into a single construct because they all characterize a student's individual affective factors associated with mathematics.

For a student with a developed mathematical self, it is typical to have: 1) developed positive attitude towards mathematics, mathematicians and a mathematics teacher; 2) developed positive perception of mathematics, mathematicians and a mathematics teacher; 3) low mathematical anxiety, high self-efficacy and positive mathematical self-conception. Characteristics of a student with an undeveloped mathematical self are as follows: 1) positive attitude towards mathematics, mathematicians and a mathematics teacher is not developed; 2) positive perception of mathematics, mathematicians and a mathematics teacher is not developed; 3) high mathematical anxiety, low self-efficacy and negative mathematical self-conception. It is important to emphasize, however, that there is a range of mathematical self, not just the two opposite positions of self. In the current research, the opposing positions were marked as developed and undeveloped mathematical self in order to conduct the quantitative study and statistical analysis of data.

Further, the previously mentioned indicators of mathematical self will be defined.

Mathematical self-conception is students' perception of or opinion about their own mathematical abilities, confidence in their ability to learn mathematics (Reyes, 1984). According to the social comparison theory, the mathematical self-conception is developed based on external references (the direct comparison of one's achievements with the achievements of other students in the immediate environment) and internal references (the direct comparison of one's achievements in a particular subject with the achievements in other school subjects) (Marsh & Hau, 2003).

Self-efficacy is an evaluation of one's competence in doing something in a certain context (Pajares & Miller, 1994). Self-efficacy is considered to be a significant factor influencing achievement in mathematics. Researchers claim that it is more important than the overall ability of the human mind, gender, mathematics learning experience, mathematical anxiety, mathematical self-conception and beliefs about the usefulness of mathematics (Pajares & Miller, 1994; Stevens, Olivarez & Hamman, 2006). Students with higher mathematical self-efficacy are able to work longer on complex mathematical problems and have fewer mistakes in calculation (Collins, 1982; Hoffman & Schraw, 2009).

Mathematical anxiety is a multidimensional psychological construct that involves complex factors such as the feeling of pressure, inappropriate behaviour that interferes with working with numbers and solving mathematical problems in different everyday situations and in academic contexts (Kazelskis, 1998).

Perception is the process by which information, obtained by the senses, is organized and interpreted to create a meaningful experience (Lindsay & Norman, 1977). Students'

perception of mathematics and mathematicians is influenced by a learner's internal factors (beliefs, attitude, previous knowledge etc.) and the context in which the perception takes place – teaching/learning methods and content as well as teachers' actions.

Within the current research, *attitude towards mathematics* is defined as like or dislike feelings towards mathematics, tendency to engage in or avoid mathematical activities, a belief that one is or is not good at mathematics as well as views on usefulness of mathematics (Kislenko, Grevholm & Lepik, 2009).

Methodological Framework and Participants

In the present study, the mixed methods approach is used which implies integrating quantitative and qualitative research methodology.

Quantitative data collection methods:

1. The survey on mathematics teachers' beliefs (Lepik & Pipere, 2011) for 7th–9th grade mathematics teachers which has been developed in order to compare Baltic and Nordic mathematics teachers' beliefs about mathematics education. In the current paper, the author has used the parts of the survey related to teachers' beliefs on effective teaching, teachers' beliefs on effective mathematics teaching and learning and teachers' self-reports about their own classroom practices.
2. The survey on non-cognitive skills for 9th grade students (Morony, Kleitman, Lee & Stankov, 2013). In the current research the author uses only the parts of the survey which contain statements about mathematical self-efficacy, mathematical self-conception and anxiety.

Qualitative data collection methods:

1. Visual research method – 9th grade students' drawings (mathematicians, mathematics);
2. Mathematics teachers' phenomenological interviews;
3. 9th grade students' phenomenological interviews;

The phenomenological interviews lasted 19 to 38 minutes. All the interviews were fully transcribed. The phenomenological analysis consisted of the following steps (Hycner, 1999): 1) bracketing and reduction; 2) delineating units of meaning; 3) clustering of units of meanings to form themes; 4) summarising each interview, validating; 5) extracting general and unique themes from all the interviews and making a composite summary. The aim within the analysis was the reconstruction of the inner world of experience of the subject. Each individual has his/her own way of experiencing temporality, spatiality, materiality but each of these coordinates must be understood in relation to the others and to the total inner "world" (Hycner, 1999). (See Appendix 1 for interview questions).

4. Projective verbal methods:
 - a) unfinished sentences method for 9th grade students about mathematics, mathematicians and mathematics teachers;
 - b) mathematics teachers' metaphors about a teacher's profession.

Research participants

The total number of participants in empirical research – 3478;

- In the survey for 7th – 9th grade mathematics teachers 390 teachers have taken part; simultaneously, metaphors from 353 respondents have been gathered and four of these teachers have participated in phenomenological interviews.
- In the survey for 9th grade students a total of 3083 students have taken part; the unfinished sentences method has been also included in the survey and drawings from 61 student of the total number of respondents have been gathered.
- In phenomenological interviews five 9th grade students have participated.

The participation in the research was voluntary and participants represented schools from provincial towns and country as well as towns; schools with general education and minority education programs. Mathematics teachers represented all five regions of Latvia and all age groups of teachers, but the dominant age group is that of 40 to 49 years. Approximately a half of the teachers had Bachelor degree and a half – Masters degree. There were a bigger number of teachers coming from provincial towns and country than those who live in towns and capital Riga. Approximately 25% of all teachers participating in this research worked in schools with minority education program. Most of the 9th grade students who took part in the research came from schools with general education program, the number of boys and girls were almost evenly distributed as well as the number of students who come from cities and towns and those from provincial towns and country. Participants of the phenomenological interviews were chosen to represent all socio-demographic groups.

Findings

Quantitative analysis of relationship between 9th grade students' mathematical self-efficacy, self-conception, anxiety and mathematics teachers' teaching approaches

At first, the author has focused on three indicators of 9th grade students' mathematical self – mathematical self-efficacy, self-conception, anxiety – and 7th–9th grade mathematics teachers' beliefs about teaching approaches and teachers' self-reports about their own classroom practices. All these indicators were studied in relation to the socio-demographic variables. In the process of the analysis, teachers' beliefs and self-reports about their own teaching approaches were studied in more detail, differentiating factors which constitute the approaches – teachers' beliefs about effective teaching, beliefs about effective mathematics teaching and the self-reports about their own classroom practices – and classifying them as corresponding to the constructivist or the traditional teaching approach.

Comparison of interest rate of standardised factors, central tendency, the average ranking of students' mathematical self-efficacy, self-conception and anxiety in different socio-demographic groups

Figure 1 shows mean values of mathematical anxiety, self-efficacy and self-conception for urban and rural students.

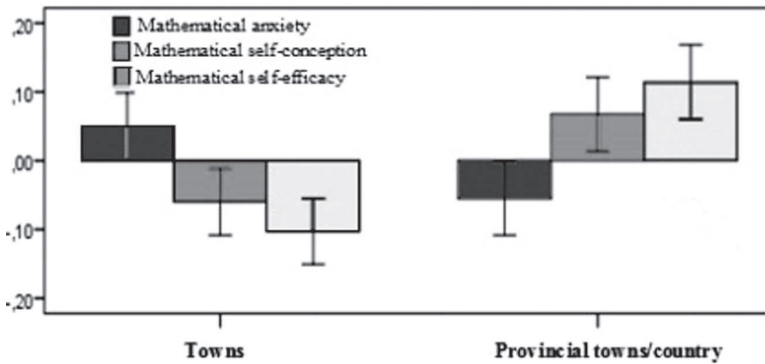


Figure 1. Mean values of mathematical anxiety, self-efficacy and self-conception for urban and rural students

There are statistically significant differences in all three factors between urban and rural students. According to quantitative indicators, mathematical self of rural students is more developed (lower mathematical anxiety, higher mathematical self-efficacy and more positive mathematical self-conception) (T-test for interdependent samples, $p < 0,05$).

Figure 2 shows mean values of mathematical anxiety, self-efficacy and self-conception in general and minority education programs.

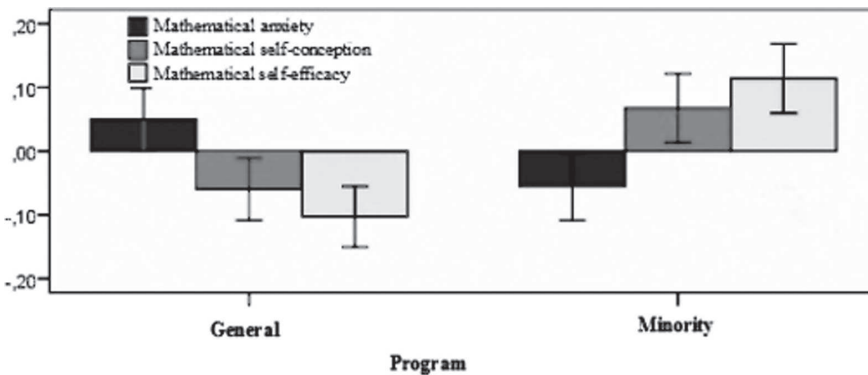


Figure 2. Mean values of mathematical anxiety, self-efficacy and self-conception in general and minority education programs

Statistically significant differences have been found only in mathematical self-efficacy (T-test for independent sample, $p < 0,001$). Students who study in education programs for minorities have higher mathematical self-efficacy.

Figure 3 shows mean values of mathematical anxiety, self-efficacy and self-conception for boys and girls.

All three factors depend on respondents' gender (T-test for independent samples, $p < 0,05$). Girls have higher mathematical anxiety and lower mathematical self-efficacy and self-conception than boys. The most significant differences were found in mathematical self-efficacy.

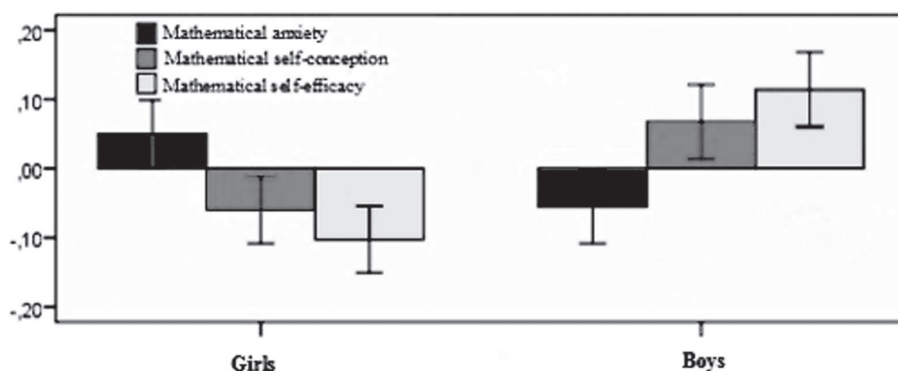


Figure 3. Mean values of mathematical anxiety, self-efficacy and self-conception for boys and girls

Analysis of correlation between mathematics teachers' teaching approach and students' mathematical self-efficacy, self-conception and anxiety

The students were divided into two clusters (two-stage cluster analysis):

Cluster 1 (51% of all the respondents, $n=1482$) – developed indicators of mathematical self: mathematical self-efficacy and self-conception higher than the mean value, mathematical anxiety lower than the mean value.

Cluster 2 (49% of all the respondents, $n=1423$) – undeveloped indicators of mathematical self: mathematical self-efficacy and self-conception lower than the mean value, mathematical anxiety higher than the mean value (Figure 4).

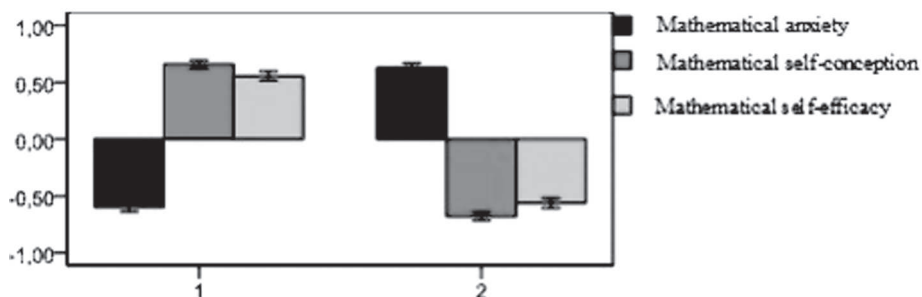


Figure 4. Mean values for standardised factors in two identified clusters

The teachers were divided into three clusters (two-stage cluster analysis):

Cluster 1 ($n=82$ (39.2% of all the teachers)) – teachers who are in favour of the constructivist teaching approach (beliefs supporting constructivist teaching approach about effective teaching and effective mathematics teaching higher than mean value, the teachers' self-reports about their own classroom practices correspond to constructivist teaching approach, support using constructivist teaching approach in the classroom).

Cluster 2 ($n=76$ (36.4% of all the teachers)) – teachers who equally support the constructivist and the traditional teaching approaches (the teachers' beliefs about effective teaching correspond more to principles of constructivism but they support the traditional teaching approach as well, in their beliefs about effective mathematics teaching/learning,

they equally support the traditional and the constructivist teaching approach and, in their classroom practices, they slightly prefer the traditional teaching approach).

Cluster 3 ($n=51$ (24.4% of all the teachers) – teachers who support the traditional teaching approach (the teachers' beliefs about effective teaching and effective mathematics teaching/learning higher than mean value, classroom practices correspond to traditional teaching approach, support using the traditional teaching approach in the classroom).

Further, the author has studied the distribution of students with developed and undeveloped indicators of mathematical self in the three identified clusters of teachers. The teachers who support the constructivist teaching approach have been marked with "K", the teachers who support both the constructivist and the traditional teaching approach – with "T+K" and the teachers who support the traditional teaching approach – with "T" (Figure 5).

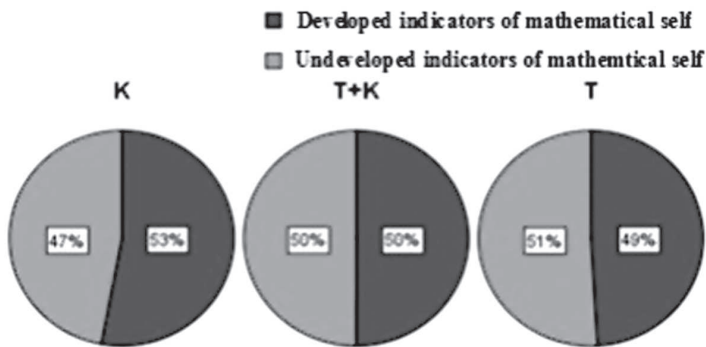


Figure 5. Comparison of students' mathematical self-efficacy, self-conception and anxiety in relation to teaching approach chosen by a teacher

As it can be seen in Figure 5, there is no strong correlation between the teaching approach chosen by a teacher and the studied indicators of students' mathematical self, ($\chi^2=3,31$, $p<0,191$). However, the indicators for students whose teachers prefer constructivist teaching approach are slightly more developed.

The research results show the difference between the impact of teachers' beliefs and self-report about their own classroom practices on students' indicators of mathematical self: self-efficacy, self-concept and anxiety. It has been found out that teachers' constructivist beliefs do not have a positive impact on the indicators of students' mathematical self, while the use of constructivism in the classroom influence these indicators positively. The analysis of the impact of teachers' socio-demographic parameters shows that there are several correlations between these parameters, the teaching approach and the indicators of students' mathematical self. It can be concluded that students' mathematical self-efficacy, self-conception and anxiety depend not only on the teaching approach used by a teacher, but rather the interaction of several factors, which include students' gender characteristics, place of living, education program and a number of factors specific to the teachers as experience, education and age.

Qualitative analysis of 9th grade students' perception of and attitude towards mathematics, mathematicians and a mathematics teacher

Latvian 9th grade students' attitude towards mathematics, mathematicians and a mathematics teacher has been studied using the *unfinished sentences method*. Students' answers about mathematics can be divided into three most common categories:

- 1) an important school subject ($n=477$) "*Mathematics is very important for me*";
- 2) a favourite school subject ($n=474$) "*Mathematics is one of my favourite subjects because I like calculations*";
- 3) a school subject/lesson ($n=280$) "*Mathematics is just a class to sit through at school*".

Mathematics as a school subject associates for many students with positive emotions ($n=873$; 41%). Some of the students with positive emotional attitude towards mathematics have pointed out that they are good at mathematics and the subject is easy, for example, "*Mathematics is one of my favourite subjects and I think I'm good at it*". A neutral view on mathematics has been identified in 788 students' answers (37%). In these answers mathematics is characterized just as a school subject or as a normal or an important school subject: "*Mathematics is a school subject*". Negative emotions have been identified in 469 students' answers (22%). Mathematics is difficult, according to these students, which is the cause for dislike. The subject seems unfamiliar, boring and fear-provoking. Despite the fact that a pronounced majority of the students consider mathematics important, there are some students who believe that the subject is insignificant, which is the cause of their indifference to it.

Three most frequently mentioned categories in students' answers about mathematicians were the following:

- 1) Smart ($n=1140$): "*Mathematicians are smart people who can find something new and interesting on our planet. Discover many secrets of the world*";
- 2) Good people ($n=268$): "*Mathematicians are very good people*";
- 3) Very smart ($n=186$): "*Very smart people because I think that mathematics is a very difficult subject. Not everybody can become a mathematician*".

The majority of the students have neutral emotions ($n=1657$; 72%). For these students a mathematician is just a person whose job is connected with mathematics, one who is good at it and has a developed logical thinking: "*People who work with many different numbers and tasks every day*". A positive emotional attitude has been identified in 414 students' responses: "*Very unique personalities, who over centuries have discovered universal techniques to make our lives easier*". In this category, a mathematician has been mainly portrayed as a smart, respected, responsible, diligent person worth of admiration and indispensable in the society. A negative emotional attitude has been identified in 230 (10%) responses. These students describe a mathematician as being different from other people because of the unusual appearance, character attributes or cognitive abilities: "*[They] have invented stupid formulas to make our life more complicated. [They] hate children and think only about themselves and the stupid mathematics*" or "*People with their imaginary ideal world, in which only mathematics exists*".

Most of the students 79.68% ($n=1859$) have a positive emotional attitude towards their mathematics teachers. In the description of a good mathematics teacher students mention personal characteristics, professional skills and appearance.

The analysis of students' drawings shows that students' vision of mathematics is mainly associated with: 1) numbers (87%), including mathematical operations: addition, subtraction, multiplication and division; 2) geometrical figures (80%) as circles, triangles, squares, etc.; 3) books (46%); 4) school supplies (37%): pens, pencils, rulers, erasers; 5) a board (34%); 6) furniture (27%): benches, tables; 8) people (15%). Many drawings contain several things from this list. The students involved in the study see a mathematician as 1) a lonely middle-aged man with glasses, dressed in a suit and working with numbers; 2) a glad middle-aged woman who is a mathematics teacher at school; 3) a thoughtful or an angry student who is forced to learn mathematics at school.

The results of students' *phenomenological interviews* show that students prefer mathematics lessons which are organized according to the principles of the constructive teaching approach.

Qualitative analysis of Latvian 7th–9th grade mathematics teachers' beliefs about teaching, their profession and self-reports about their own classroom practices

According to the 7th–9th grade mathematics teacher's metaphor analysis, the teachers have a personal interest in their work, they consider the skills to teach the subject matter well having good knowledge of teaching methods and approaches as very important, and a significant role in the teaching/learning process is played by a student's emotional well-being. All the previously mentioned characteristics indirectly indicate teachers' support to the constructivist teaching approach, since introducing this approach in teaching/learning process requires knowledge and skills for organising effective teaching/learning process and establishing a positive emotional climate. The large number of hybrid metaphors proves the fact that teachers are aware of the multifaceted nature of their work and realise that the organization of a successful teaching/learning process requires different skills and knowledge from a teacher. The dominance of self-directed metaphors can imply that the teachers do not separate their role as a teacher from other social roles; they relate their work to themselves, as a person.

According to the mathematics teachers' phenomenological interviews, teachers' descriptions of an everyday and an ideal mathematics lesson largely coincide and tend to conform more to the constructivist teaching approach rather than the traditional teaching approach, which indicates that the interviewed teachers both prefer and try to use elements of the constructivist teaching approach in their everyday lessons.

The relationship between mathematics teachers' teaching approaches and 9th grade students' mathematical self – integration of qualitative and quantitative data

The quantitative data analysis has revealed that the constructivist teaching approach has a slightly more positive impact on the indicators of students' mathematical self – self-efficacy, self-conception and anxiety – than the traditional teaching approach. The analysis of students' qualitative data has shown that students prefer the constructivist teaching approach thus giving an indication of the positive effect of the constructivist teaching approach on students' attitude towards mathematics as well as perception of mathematics and mathematicians.

Although the mathematics teaching/learning process is a complex process, influenced by several internal and external factors, the tendencies indicate a positive impact of

using the constructivist approach in mathematics teaching/learning process on development of quantitative and qualitative indicators of students' mathematical self, taking into consideration that all these indicators correlate and are mutually related.

Conclusion

The findings from the study suggest the following conclusions. Firstly, teachers' work at school is largely determined by their beliefs, which are based on an individual's philosophical view on mathematics and mathematics teaching/learning process in correlation with such contextual factors as a teacher's education, work experience, place of residence and educational program realised at school.

Secondly, an important role in mathematics teaching/learning process is played not only by students' cognitive skills, but also a student's mathematical self, which includes such qualitative indicators as students' perception of mathematics, mathematicians and a mathematics teacher and attitude towards them as well as quantitative indicators such as mathematical self-efficacy, self-conception and anxiety. All the indicators of mathematical self are interrelated and characterise a student's individual affective factors related to mathematics.

Thirdly, the use of constructivism in mathematics teaching/learning process contributes to establishing positive learning environment in the classroom with emphasis on cooperation and students' active participation in the teaching/learning process and the development of their knowledge and skills, relating knowledge with the daily life necessities, the teacher's role as an advisor and students' emotional well-being in the classroom thereby positively influencing students' mathematical self. This corresponds with principles of sustainable education, according to which the aim of education is to develop not only intellectual, but also emotional, social and spiritual potential, moving the focus from teaching specific facts to creation of an environment which would stimulate students' creative and cognitive interaction with the world.

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