View of mathematics – an investigation of Estonian university students

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This study reports on first-year Estonian university students' view of mathematics. The data was collected from 970 university students of different disciplines. The participants filled out a Likert-type questionnaire that was developed using previously published instruments. This paper documents and analyses the data from the study. In this study students agreed that mathematics is an important and valuable subject. Female students have a more positive view of mathematics than male students. Science students have a more positive view of mathematics than non-science students.

Despite the prevalence of research into beliefs, there is considerable debate about the definition and characteristics of beliefs. This has led to a proliferation of terms and various uses of "belief" to describe elements of students' cognition. Other researchers have noted this and described beliefs as a "messy construct" with different interpretations and meanings (Pajares, 1992). Much of this "messiness" stems from researchers' desires to distinguish between beliefs and knowledge (Speer, 2005). Although debate continues, definitions found in the mathematics education literature focus primarily on how teachers view the nature of mathematics and the nature of teaching and learning (Speer, 2005).

Recent surveys of the literature (Furinghetti & Pehkonen, 2002; Hannula, Kaasila, Laine & Pehkonen, 2006; McLeod & McLeod, 2002) conclude that no consensus of definition has emerged yet. In the expanding field of research, several different definitions were given for the central concepts. Furinghetti and Pehkonen (2002) wanted to identify the common ground for discussing the mathematics-related affect and, therefore, asked a virtual panel of mathematics education researchers to evaluate different definitions that these same researchers had suggested

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for the concepts *attitude*, *belief* and *conception* in their papers. Sadly, the researchers could not agree on any of their definitions.

The *view of mathematics* indicator was developed in 2003 as part of the research project "Elementary teachers' mathematics" financed by the Academy of Finland (Hannula et al., 2006). Rösken, Hannula and Pehkonen (2011) continued developing this conception and obtained seven dimensions in which upper secondary school students' hold beliefs and emotions about mathematics partly intertwined with their motivational orientations. These dimensions are described by reliable scales, which allow the outlining of an average image of Finnish students' views of themselves as learners of mathematics. In another study, Kaldo and Hannula (2012) confirmed that several different attitudes, beliefs and motivational orientations can be identified and validly measured as separate components of Estonian university students' view of mathematics.

Kislenko (2009) concluded in her study, that amongst students from the 7th, 9th and 11th grades in Estonia, mathematics is important, but boring. Kislenko (2011) also concluded that students liked it when they understood mathematics, but disliked it when they did not understand. Another reason for liking mathematics was a student's feeling of being competent in mathematics. She concluded that a teacher must be an expert in his/her subject and a likable teacher is one who has the ability to explain and support understanding. Pepin (2011) compared English and Norwegian students' (aged 11–16) attitude towards mathematics and concluded that mathematics is interesting, but hard and challenging for some, while being boring and frustrating for others. She also concluded that in both countries students enjoyed group work in classrooms in order to understand mathematics better. In addition, Pepin's (2011) study showed that in Norway and England students stressed the role of the teacher in helping them to learn and do mathematics. A study by De Corte and Op 't Eynde (2003) showed that girls did not have more positive mathematics-related beliefs than boys in any educational track of the Belgian school system. In humanities, boys had significantly more positive beliefs about themselves than girls. This indicates that the relationship between beliefs, gender and context is a rather complex one. Andrews, Diego-Mantecón, Op 't Eynde and Sayers (2007) discovered that girls both in Spain and England, regardless of age or nationality, were less positive in their beliefs about their own competence than boys. In terms of mathematics being inaccessible and elitist, they found that both males and females shared this negative view; however, females had a significantly more negative viewpoint.

The study in this paper is unique in Estonia, because there have been no similar studies at the university level that aim to explore students' view of mathematics. Additionally, the ICMI Study *The teaching and learning* *of mathematics at the university level* (Holton, 2001) does not cover the field of affect and the special issue *Beliefs and beyond: affecting the teaching and learning of mathematics* of the journal ZDM (The International Journal on Mathematics Education) in 2011 does not touch the mathematics-related students' beliefs at the tertiary level. The specific research questions in this study were formulated as follows: What kinds of view of mathematics do students from Estonia hold at the university level? Is there a difference from the perspective of gender? Is there a difference from the perspective of science and non-science students' answers? In this paper, the students' view of mathematics is given together with the general results taking all answers into consideration.

Theoretical framework

Personal views of mathematics have been a topic of interest in mathematics education research for the last thirty years and have been studied from different perspectives, often closely interwoven with beliefs about mathematics (e.g. Op 't Eynde, De Corte & Verschaffel, 2002). The papers by Schoenfeld (1985, 1992) and Pehkonen (1995) contributed concerning students' beliefs about mathematics in general; McLeod (1992) and Kloosterman (1996) described the connection to affect and motivation; Lester, Garofalo and Kroll (1989) were concerned with self-concept beliefs related to mathematics problem solving.

McLeod (1992) made an important contribution to organizing the field. He suggested that mathematics-related affect should be conceptualised using the three elements *beliefs*, *attitudes* and *emotions*. In his framework motivation was conceptualized as motivational beliefs. McLeod's work in particular ushered in a new period of research on affect in mathematics education. Later, DeBellis and Goldin (1997) added a fourth element, *values*, but argued that the four types could no longer be ordered along a single stability/intensity dimension axis. The work by Furinghetti and Pehkonen (2002) tries to update the discussion on the results of different areas of research concerning this topic. Hannula (2011) suggested that mathematics-related affect has an *emotional*, a *motivational* and a *cognitive* dimension, each of which would have a state aspect and a trait aspect. Empirical studies have provided support for the separate character of these types of affective traits among Finnish students in comprehensive (Hannula & Laakso, 2011) and secondary schools (Rösken et al., 2011).

View of mathematics

The term view of mathematics was originally introduced by Schoenfeld (1985) and later adapted by others (Hannula et al., 2006; Pehkonen, 1995;

Pehkonen & Törner, 1996; Rösken et al., 2007; Rösken et al., 2011). There are contributions taking into consideration explicitly the construct views of mathematics; i.e., Schoenfeld (1985), who claims that "[b]elief systems are one's mathematical world view, the perspective with which one approaches mathematics and mathematical tasks" (p. 45). However, it remains open what kind of distinction has to be drawn between the two concepts beliefs and view.

In order to emphasize the present focus on studying the structure of students' mathematical beliefs, I use the term *view of mathematics* in this paper (Kaldo, 2011; Kaldo & Hannula, 2012; Rösken et al., 2011). Nevertheless, I am aware of the fact that usage of the term "view" is also discussed under the headline of "beliefs" in other literature. The *view of mathematics* indicator was developed in 2003 in Finland (Hannula et al., 2006). They collected data on 269 trainee teachers at three Finnish universities: Helsinki University, Turku University and Rovaniemi University. They assumed that emotions, cognitions and motivations form a system that has a quasi-logical structure. They found that view of mathematics also has a structure that coincided with the work of Op 't Eynde, De Corte and Verschaffel (2002). Later, Rösken et al. (2007) used a modified questionnaire to collect and analyze data from a sample of Finnish secondary school students. They were interested in students' view of mathematics as a result of their experiences as learners of mathematics. In their study the statements in the questionnaire were grouped around the following topics:

1) Experiences as a mathematics learner,

2) Image of oneself as a mathematics learner, and

3) View of mathematics and its teaching and learning.

They got a seven-factor solution for students' view of mathematics. These factors were: competence, effort, teacher quality, difficulty of mathematics, enjoyment of mathematics, family encouragement and confidence. Some items on motivation were included in the Finnish questionnaire used by Hannula et al. (2006) but they failed to form a reliable component.

I am interested in students' views of mathematics as a result of their experiences as learners of mathematics at the tertiary level. With regard to this focus, I pay attention to the cognitive component described by beliefs as well as to emotional and motivational aspects. This choice of concept draws on the following aspects: first, beliefs are often considered to be on a more cognitive side of the affect (e.g., McLeod, 1992). Using "view" instead of "beliefs", I want to emphasize that not all dimensions that are addressed are cognitive ones. Second, I consider the term ”view” more appropriate to capture the structural properties of the affect–cognition interplay in social learning situations. In some sense, the term ”beliefs” is separate while ”view” is holistic (Rösken et al., 2011).

Structure of view of mathematics

Op ’t Eynde et al. (2002) and Op ’t Eynde and De Corte (2003) suggest a different approach to structuring beliefs on mathematics. Op ’t Eynde and De Corte (2003) gave this definition:

> Students’ mathematics-related beliefs are the implicitly and explicitly held subjective conceptions students hold to be true about mathematics education, about themselves as mathematics learners, and about the mathematics class context. These beliefs determine in close interaction with each other and with students’ prior knowledge their mathematical learning and problem-solving activities in class. (Op ’t Eynde & De Corte, p. 4).

In terms of the framework suggested by Op ’t Eynde et al. (2002) and Op ’t Eynde and De Corte (2003), the cognitive dimensions can be assigned to all the main categories and to most of the subcategories:

1. Beliefs about mathematics education:
   a) beliefs about mathematics as a subject (difficulty of mathematics),
   b) beliefs about mathematical learning and problem solving (difficulty of mathematics), and
   c) beliefs about mathematics teaching in general.
2. Beliefs about self:
   a) self-efficacy (ability, success),
   b) control beliefs (effort),
   c) task-value beliefs, and
   d) goal-orientation beliefs.
3. Beliefs about the social context:
   a) beliefs about the social norms in their own class (beliefs about the role and functioning of the teacher and the students), and
   b) beliefs about socio-mathematical norms in their own class.

In the above classification students’ beliefs about mathematics education reflect the students’ view on what mathematics is like; the perspective with which they approach mathematics and mathematical problem solving and tasks. In this model, the example for beliefs about mathematics teaching is "a good teacher first explains the theory, then gives an example of an exercise before he asks students to solve mathematical problems". Students' beliefs about self in relation to mathematics are motivational beliefs: expectancy, value and affect. Expectancy components refer to students' beliefs that they can accomplish a task; i.e., self-efficacy beliefs (for example, "I am confident I can understand the most difficult material presented in the readings of this mathematical course") and control beliefs (for example, "if I study in appropriate ways, then I will be able to learn the material in the course"). More details about the concepts of beliefs for these categories can be found in the framework of Op 't Eynde et al. (2002).

Op 't Eynde et al. (2002) claimed that at the moment there is little empirical evidence supporting their categorization and there is a need for more questionnaire studies that show through factor analysis how categories and subcategories of students beliefs are empirically valid. Rösken et al. (2011) obtained seven dimensions for students' views of themselves as learners of mathematics, which can be assigned to different topics around their experiences with mathematics. Their categorization coincides with the work of Op 't Eynde et al. (2002). Rösken et al. (2011) found that three factors relate to personal beliefs since a clear self-relation aspect regarding ability, effort and success can be found. Although the factors ability and success both deal with the capacity to learn mathematics, they clearly broach different issues. Two factors relate primarily to students' support by their teacher and family (the factors teacher quality and family encouragement), one to emotions (the factor enjoyment of mathematics) and one to mathematics as a subject (the factor difficulty of mathematics). Six of the attained dimensions deal with beliefs about mathematics. One dimension (enjoyment of mathematics) expresses a clear emotional statement, whereas a motivation scale could not be found (Rösken et al., 2011).

The studies by Kaldo (2011) and by Kaldo and Hannula (2012) confirmed that several different attitudes, beliefs and motivational orientations can be identified and validly measured as separate components of Estonian university students' view of mathematics. The study by Kaldo and Hannula (2012) confirmed that dimensions of view of mathematics can be assigned to all the main categories and to most of the subcategories:

1. Beliefs about mathematics education – beliefs about mathematical learning and problem solving (mathematics as rote-derived knowledge);

2. Beliefs about self
   a) self-efficacy beliefs (competence, attitudes to mathematics),
   b) control beliefs (effort, cheating behaviour),
   c) task-value beliefs (relevance, personal value of mathematics), and
   d) goal-orientation beliefs (performance-approach goal orientation, mastery goal orientation);
3. Beliefs about the social context – beliefs about social norms (teacher role).

This structure (Kaldo & Hannula, 2012) coincides with the work of Op 't Eynde et al. (2002), Rösken et al. (2011) and Pepin (2011).

Some previous results concerning mathematics-related beliefs

Some studies about students' and teachers' attitudes in comprehensive schools or in upper-secondary schools have been carried out in Estonia (Kislenko, 2009; Lepmann, 2000; Lepmann & Afanasjev, 2005; Pehkonen & Lepmann, 1994). The study of Lepmann and Afanasjev (2005) revealed that high-attaining pupils have considerably greater faith in achieving success in mathematics learning than low-attaining pupils. Compared to other pupils, high-attaining pupils are considerably more desirous of each pupil being able to work according to his or her ability. They want to develop their ability and are ready to do more work in the name of success. However, low-attaining pupils are more disposed to giving up than pupils with a high attainment.

Kislenko's (2009) more recent results indicated that students in comprehensive and secondary schools perceive mathematics to be important, but studying it tends to be difficult and boring. In another study, Sumpter (2012) investigated Swedish secondary school students' gender stereotyping of beliefs describing the aspects safety, expectations and motivation. Among the statements that were considered gendered, girls seem to be connected to beliefs about aspects of expectations and safety: what you are expected to do and what is considered a safe strategy. Boys are assigned beliefs about what to expect from a graphic calculator.

Recently the British researchers Abdulwahed, Jaworski and Crawford (2012) presented a survey of emerging trends of using constructivist approaches in teaching mathematics in science and technology higher education. They pointed out that there is a growing awareness that more research is needed to get to grips with issues concerning students' engagements with mathematics in higher education.

However, there have been only a few investigations of students' views of mathematics in Estonia at the university level and thus in the present day it is an unexplored area in Estonia. In the Nordic countries and Baltic States, the field of affect in mathematics at the university level is an almost uncovered theme. In these countries only a few studies at the university level have been conducted (Juter, 2005).

Method

This survey covered a sample of students drawn from the first year mathematics course of five universities in Estonia. The participants were 970 students who had taken at least one compulsory first-year mathematics course. They participated in the study on a voluntary basis. The age of the participants ranged between 18 and 34; the average age was 20. Of the participants, 508 were males and 462 were females. There were 498 science and 472 non-science students. The participants filled in the questionnaire on paper responding to a four-option Likert-scale (strongly disagree, SD, partly disagree, PD, partly agree, PA and strongly agree, SA). The factors are described in the work Kaldo and Hannula (2012). The composed instrument consisted of the following elements of students' view of mathematics:

Performance-approach goal orientation (Midgley et al., 2000), 4 items,

Mastery goal orientation (Midgley et al., 2000), 6 items,

Mathematics as a rote-learnt subject (Diego-Mantecon et al., 2007), 4 items,

Attitudes to mathematics (Yusof & Tall, 1994), 6 items,

Relevance (Diego-Mantecon et al., 2007), 9 items,

Personal value of mathematics (OECD, 2009), 3 items,

Students competence (Rösken et al., 2011, 3 items; Diego-Mantecon et al., 2007), 3 items;), 6 items in total,

Teacher role (Diego-Mantecon et al., 2007), 5 items,

Cheating behaviour (Midgley et al., 2000), 3 items, and

Effort (Rösken et al., 2011), 4 items.

In this instrument, seven factors had reasonably good Cronbach's alpha (0.70–0.82) and their reliability for Estonian university students was confirmed (Kaldo & Hannula, 2012). The structure of students' view of mathematics in this paper was assumed to consist of the following confirmed factors (Kaldo & Hannula, 2012):

Performance-approach goal orientation (Cronbach's alpha 0.78, sample item: "One of my goals is to show others that I am good at my class work"),

Mastery goal orientation (Cronbach's alpha 0.74, sample item: "It is important to me that I learn a lot of new mathematical concepts this year."),

Relevance (Cronbach's alpha 0.82, sample item: "A knowledge of mathematics is important; it helps us to understand the world"),

Personal value of mathematics (Cronbach's alpha 0.70, sample item: "Mathematics is useful for our society"),

Student competence (Cronbach's alpha 0.82, sample item: "I think that what I am learning in mathematics is interesting"),

Teacher role (Cronbach's alpha 0.72, sample item: "My lecturer tries to make mathematics lessons interesting.") and

Cheating behaviour (Cronbach's alpha 0.82, sample item: "I sometimes cheat while doing my class work.").

The article Kaldo and Hannula (2012) focused on developing the concept of view of mathematics and analysing the instrument. The article Kaldo and Reiska (2012) concentrated on correlations between the confirmed factors. In both of these works no statement analyses were done.

Data analysis and results

In the following section, I will present several results of my data analysis. Frequency tables are supposedly the most informative presentation of ordinal data (Kislenko, 2009). Based on the research questions, 35 statements from the survey were considered in the analysis. The following paragraph presents the frequency tables for every separate factor in order to give the general picture of the results and introduces the differences between science/non-science students (see appendix A) and gender (see appendix B). In the tables all numbers are in percentages. SA means strongly agree, PA means partially agree, PD means partially disagree and SD means strongly disagree. The percentage of the answers of every item is presented in the tables (at a sum total of 100%). The means and standard deviation of the items are excluded from the analysis, as these were not considered to be illustrative of this type of data (Kislenko, 2009; Kislenko & Grevholm, 2008). In this paper I use the Spearman's correlation coefficient because the data are ordinal (Kislenko, 2009). Spearman's test works by first ranking the data and then applying Pearson's equation to those ranks. According to Hinkle, Wiersma and Jurs (2009), the strength of the correlation can be classified as little if any (0.00 to 0.29), low (0.30 to 0.49) to moderate (0.50 to 0.69) or high (0.70 to 0.89) in the survey. At least moderate correlations coefficients, which are greater than 0.5, are presented in this study. The presented correlations are significant at the 0.01 level.

Performance-approach goal orientation

Approximately 2/3 of the students agreed that it is important to them that other students in their class think they are good at their class work, but for 57 % of the students it is not important to show others that they are good at their class work (table 1). For 72 % of the students it is not important to them that they look intelligent compared to others in their class. In general, no differences between science and non-science students' answers (see appendix A) and no gender differences were found (see appendix B). The correlation coefficient between statements S15 and S16 is 0.609 and between statements S26 and S27 is 0.574.

Mastery goal orientation

In general, students tended to be more positive in their opinions as they more often chose "strongly agree and partially agree". 78 % of students agreed that it is important to them that they improve their skills this year in mathematics (table 2). 43 % of students are not motivated to study mathematics. For 89 % of students it is important to them that they thoroughly understand their class work. 80 % of students agreed that one of their goals in class is to learn as much as they can. Science students are more motivated to study mathematics (63 %) than non-science students (51 %). In addition, 70 % of science students (compared to 59 % of non-science students) agreed that one of their goals is to master a lot of new skills this year. Based on the comparison between the genders, females have a more positive view than male students. They are more motivated to study mathematics (64 %) compared to male students (51 %). 93 % of female students agreed that it is important to them that they thoroughly

Table 1. *Performance-approach goal orientation*

	SA	PA	PD	SD
S15. It is important to me that other students in my class think I am good at my class work.	18	50	17	15
S16. One of my goals is to show others that I am good at my class work.	9	35	27	29
S26. One of my goals is to show others that class work is easy for me.	2	14	33	52
S27. It is important to me that I look intelligent compared to others in my class.	1	7	20	72

Table 2. *Mastery goal orientation*

	SA	PA	PD	SD
S17. It is important to me that I improve my skills this year in mathematics.	33	45	15	7
S52. I am very motivated to study mathematics.	17	40	31	12
S64. It is important to me that I thoroughly understand my class work.	43	45	10	1
S65. It is important to me that I learn a lot of new mathematical concepts this year.	18	45	30	8
S71. One of my goals is to master a lot of new skills this year.	18	46	28	8
S78. One of my goals in class is to learn as much as I can.	33	47	16	4

understand their class work (compared to 84 % of male students). 26 % of male students disagreed that one of their goals in class is to learn as much as they can (compared to 14 % of female students).

Relevance

Based on table 3, it is clear that students acknowledged that relevance is important in learning mathematics. 92 % of students think that mathematics is an important subject and 87 % of students agreed that some

Table 3. *Relevance*

	SA	PA	PD	SD
S22. Some knowledge of mathematics helps me to understand other subjects.	44	43	11	2
S28. Knowing mathematics will help me earn a living.	16	45	21	19
S29. I think mathematics is an important subject.	57	36	6	2
S34. Studying mathematics is a waste of time.	13	52	28	7
S49. I can use what I learn in mathematics in other subjects.	23	50	19	7
S59. I study mathematics because I know how useful it is.	36	46	15	3
S69. Mathematics enables us to better understand the world we live in.	35	44	16	6
S73. I can apply my knowledge of mathematics to everyday life	17	51	26	6

knowledge of mathematics helps them to understand other subjects. The students study mathematics because they know how useful it is (82 %) and they can apply their knowledge of mathematics to everyday life (68 %). It is surprising that 65 % of students think that studying mathematics is a waste of time. A comparison of science and non-science students' answers shows that science students have a more positive view than non-science students. 96 % of science students agreed that mathematics is an important subject (compared to 89 % of non-science students).

The correlation coefficient between statements S22 and S49 is 0.524 and between statements S29 and S69 is 0.509.

Personal value of mathematics

Table 4 shows that students have a positive view of personal value of mathematics. 79 % of students agreed that knowledge of mathematics is important and it helps us to understand the world. 76 % of students agreed that mathematics is useful for our society. 82 % of science students agreed that mathematics is useful for our society (compared to 70 % of non-science students). For all questions female students answered more than male students. 84 % of female students agreed that knowledge of mathematics is important; it helps us to understand the world (compared to 74 % of male students). 72 % of female students agreed that

Table 4. *Personal value of mathematics*

	SA	PA	PD	SD
S23. A knowledge of mathematics is important; it helps us to understand the world.	24	55	17	5
S30. Mathematics is useful for our society.	36	41	19	5
S74. After graduating university I have many opportunities to apply my mathematical knowledge.	22	44	25	9

after graduating from university, they have many opportunities to apply their mathematical knowledge (compared to 62 % of male students).

The correlation coefficient between statements S30 and S29 is 0.557 and between statements S30 and S69 is 0.754.

Student competence

80 % of students disagreed that mathematics was their worst subject in high school. 69 % of students think that what they are learning in mathematics is interesting. 63 % of students agreed mathematics is hard for them. 46 % of students think that they are good at mathematics and 46 % of students understand everything that they have done in mathematics this year (table 5).

Table 5. *Student competence*

	SA	PA	PD	SD
S24. Mathematics was my worst subject in high school.	8	12	15	65
S25. Mathematics is hard for me.	18	45	24	13
S46. I am good at mathematics.	6	41	36	18
S47. I think that what I am learning in mathematics is interesting.	21	48	22	8
S48. Compared with others in the class, I think I am good at mathematics.	6	38	40	16
S55. I understand everything we have done in mathematics this year.	12	33	34	20

The correlation coefficient between statements S47 and S52 is 0.583; between statements S24 and S46 is -0.533; between statements S25 and S46 is -0.665; and between statements S46 and S48 is 0.635.

A comparison of science and non-science students shows that science students have a more positive view; they feel more competente in mathematics. Unfortunately, only 46 % of science and 44 % of non-science students understand everything that they have done in mathematics this year. A comparison of gender difference shows that female students are more positive than male students. 74 % of female students (compared to 64 % of male students) think that what they are learning in mathematics is interesting and 52 % of female students think that they are good at mathematics (compared to 41 % of male students). Mathematics is harder for male students (65 %) than female students (61 %).

Teacher role

The students disagreed that their lecturer explains why mathematics is important (71 %), while they also disagreed that the lecturer has not been able to explain the processes they are studying. 60 % of students disagreed that their lecturer tries to make mathematics lessons interesting and 79 % disagreed that in addition to mathematics, the lecturer teaches them how to study. In general, no science and non-science students' difference was found. 45 % of female students agreed that the lecturer tries to make mathematics lessons interesting (compared to 35 % of male students). 37 % of female students agreed that the lecturer has not inspired them to study mathematics (compared to 51 % of male students).

Table 6. *Teacher role*

	SA	PA	PD	SD
S37. My lecturer explains why mathematics is important.	4	25	42	30
S53. The lecturer has not been able to explain the processes we were studying.	4	22	38	36
S54. My lecturer has not inspired me to study mathematics.	13	32	34	21
S60. My lecturer tries to make mathematics lessons interesting.	10	30	39	22
68. In addition to mathematics, the lecturer teaches us how to study.	3	18	32	47

Cheating behaviour

Table 7 shows that the students have a positive view. That means they have a negative view of cheating. 71 % of students disagreed that they sometimes copy answers from other students during tests, 71 % of students disagreed that they sometimes cheat while doing their class work and 73 % of students disagreed that they sometimes copy answers from other students when they do their homework. A comparison between science and non-science students shows that science students cheat less than non-science students. Comparing the genders shows that female students cheat less than male students.

The correlation coefficient between statements S42 and S43 is 0.699 and between statements S42 and S62 is 0.519.

Table 7. *Cheating behaviour*

	SA	PA	PD	SD
S42. I sometimes copy answers from other students during tests.	8	22	21	50
S43. I sometimes cheat while doing my class work.	8	21	22	50
S62. I sometimes copy answers from other students when I do my homework.	5	22	27	45

Conclusions and discussion

Research into mathematics education at the tertiary level may be itself an interesting field of research and may give rise to useful results for all teachers to apply to their teaching (Alsina, 2001). Based on studies carried out by researchers in other countries, it is clear that attitudes and beliefs of mathematics are important areas in mathematics education and need attention also in the Estonian context. Unfortunately, there has not been an investigation of students' views of mathematics in Estonia at the university level and thus at present this is an unexplored area in Estonia. In this research project, the sample size and representativeness of all universities is one of the strengths of the research. The results are the best data available about Estonian university students' mathematics attitudes. Previous mathematics-related research in Estonia and other countries has been done at the comprehensive or secondary school levels and this study brings new knowledge about students' view of mathematics at the tertiary level.

In the study that Hannula and Malmivouri (1997) conducted in Finland, students answered that mathematics is important and a highly used subject and at the same time they classified mathematics as boring and demanding rather than interesting and exciting. In another study, which was carried out in Norwegian and Estonian high schools by Kislenko (2009), six students out of ten thought mathematics was exciting and interesting, while every second student found it boring.

For 68 % of students in this study, it is important to them that other students in their class think that they are good at their class work, but for 72 % students it is not important that they look intelligent compared to others in their class. Eight students out of ten thought that one of their goals in class is to learn as much as they can and for nine students out of ten it is important that they thoroughly understand their class work. 57 % agreed that they are motivated to study mathematics. The conclusion is that students have a positive view of mathematics and they are very motivated to study mathematics.

The factor *Relevance* is clearly positively marked. It is positive that 92 % of students agreed that mathematics is an important subject, but at the same time 65 % of students think that studying mathematics is a waste of time. They know that mathematics is important, but they do not want to study mathematics. The reasoning can be that lecturers during mathematics lessons do not show the connections between mathematic and other subjects. The lectures are also too theoretical. The suggestion from this study is that students need more practice and practical tasks, which coincides with the work of Pepin (2011). This situation calls for change in the teaching of mathematics at the university level and is a challenge for the lecturers.

In this study, students found that mathematics is an important and valuable subject. They also found that knowledge of mathematics helps them to understand other subjects (87 %) and knowing mathematics will help them earn a living (61 %). For the students, mathematics becomes an important and useful subject when they use it in other subjects or they use mathematical knowledge to find solutions to everyday real-life problems. Additionally, Kislenko (2009) found that for students, mathematics was highly important and useful in their lives. In addition, the studies by Hemmi (2006) and Kislenko and Lepmann (2011) emphasized the importance of real-life applications.

8 students out of 10 think that knowledge of mathematics is important and it helps them to understand the world. Approximately 2/3 of students agreed that after graduating from university, they will have many opportunities to apply their mathematical knowledge. The conclusion from this study is that mathematics becomes an important and useful

subject when students can use it in other subjects or they use their mathematical knowledge to find solutions to everyday real-life problems. This claim is important to lecturers so they can change their teaching methods at the university level. The suggestion for lecturers is that students must be able to identify how mathematics is valuable in everyday life and their future careers.

Most of the students disagreed that mathematics was their worst subject in high school and less than half of the students agreed that they are good at mathematics. More than 2/3 of the students think that what they are learning in mathematics is interesting. Almost half of the students say that they have understood everything that they have done in mathematics this year. Considering that "I have understood everything that I have done in mathematics this year", is a very strong statement, this must be seen as a positive result. Despite some positive and encouraging results, the overall impression is that a change in teaching techniques in mathematics at the university level is called for, and this is a challenge to lecturers. The suggestion for teaching and learning mathematics is that the students need additional materials (tutorials, books, lecture notes, webpages, etc.) to study mathematics at home and for revising mathematics after lectures. The solution can also be that students need consultation time in mathematics.

The factor *Teacher role* gives some suggestions for teaching practice. Students need lecturers to explain more why mathematics is important and make the mathematics lessons more interesting. In addition, lecturers do not teach how to study mathematics. Mathematics lessons seem to be boring, which is consistent with Kislenko's (2009) work. Op 't Eynde and De Corte (2003) concluded that how students feel accepted by the teacher and find the teacher sensitive to their needs seemed to be related to how motivating they perceive their teacher to be and how he organizes instruction.

In the factor *Cheating behaviour*, students are more delineated in their opinions. Half of the students totally disagreed with cheating. At the same time it is worrying that almost 30% admits to have cheated on a test. The reason for cheating is probably the fear of dropping out. It is important to note that the reasons why some students may cheat can be of a practical nature; for example, they need to get a good grade in order to get a scholarship or some other benefits. There is a need for change in the teaching of mathematics at the university level to prevent cheating. The tests must be worked out in such a way that students can not simply cheat but they need to analyse or find a connection between their knowledge or that the tests are practical tasks instead of only proving theorems.

The correlation coefficients between the questions are moderate, 0.509–0.754. These correlations coefficients are found in the following factors: *Performance-approach*, *Goal orientation*, *Relevance*, *Personal value of mathematics* and *Student competence*. The medium correlation is between the following: knowledge of mathematics helps students to understand other subjects and they can use this knowledge in other subjects. Students think that mathematics is important and mathematics enables them to better understand the world they live in. Moreover, students think that mathematics is useful for our society and that mathematics is an important subject. The moderate correlation is between the following: students are motivated to study mathematics and mathematics is interesting. Furthermore, students think that mathematics is hard for them but they are good at mathematics.

Gender differences are found in the factors *Mastery goal orientation*, *Relevance*, *Personal value of mathematics*, *Student competence*, *Teacher Role* and *Cheating behaviour*. Female students have a more positive view of mathematics than male students. For these factors, female students answered almost all the questions more positively than male students. Female students think that mathematics is interesting and they are good at it. Mathematics is harder for male students than female students.

Comparing science and non-science students, a difference has been found in the factors *Mastery goal orientation*, *Relevance*, *Personal value of mathematics*, *Student competence* and *Cheating behaviour*. Science students have a more positive view of mathematics than non-science students. Science students are more motivated to study mathematics. Both groups mentioned that mathematics is an important subject and useful for our society.

Summarising here, students think that mathematics is an important, useful and valuable subject and they have a positive view of mathematics.

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Appendix A

Science and non-science students' comparison

Performance-approach goal orientation		**SA**	**PA**	**PD**	**SD**
S15. It is important to me that other students in my class think I am good at my class work.	science	17	50	19	14
	non-science	19	50	15	16
S16. One of my goals is to show others that I am good at my class work.	science	10	33	27	31
	non-science	8	37	27	28
S26. One of my goals is to show others that class work is easy for me.	science	2	14	31	53
	non-science	1	14	35	51
S27. It is important to me that I look intelligent compared to others in my class.	science	1	6	20	73
	non-science	1	8	20	73

Relevance		**SA**	**PA**	**PD**	**SD**
S22. Some knowledge of mathematics helps me to understand other subjects.	science	50	41	8	2
	non-science	38	45	14	3
S28. Knowing mathematics will help me earn a living.	science	19	47	18	16
	non-science	13	43	24	21
S29. I think mathematics is an important subject.	science	64	32	3	1
	non-science	49	40	9	2
S34. Studying mathematics is a waste of time.	science	15	52	31	7
	non-science	11	51	26	7
S49. I can use what I learn in mathematics in other subjects.	science	29	50	15	6
	non-science	17	51	24	9
S59. I study mathematics because I know how useful it is.	science	37	49	12	2
	non-science	34	44	19	4
S69. Mathematics enables us to better understand the world we live in.	science	39	46	12	3
	non-science	30	41	20	9
S73. I can apply my knowledge of mathematics to everyday life.	science	19	52	24	5
	non-science	15	50	28	7

Mastery goal orientation		SA	PA	PD	SD
S17. It is important to me that I improve my skills this year in mathematics.	science	35	45	14	6
	non-science	32	45	16	8
S52. I am very motivated to study mathematics.	science	17	46	29	8
	non-science	17	33	33	17
S64. It is important to me that I thoroughly understand my class work.	science	46	44	9	1
	non-science	41	47	12	1
S65. It is important to me that I learn a lot of new mathematical concepts this year.	science	19	45	31	5
	non-science	16	44	28	11
S71. One of my goals is to master a lot of new skills this year.	science	21	49	25	5
	non-science	15	43	30	11
S78. One of my goals in class is to learn as much as I can.	science	35	45	17	3
	non-science	32	48	16	5

Personal value of mathematics		SA	PA	PD	SD
S23. A knowledge of mathematics is important; it helps us to understand the world.	science	22	54	19	5
	non-science	26	56	14	4
S30. Mathematics is useful for our society.	science	41	41	16	2
	non-science	30	40	22	8
S74. After graduating university I have many opportunities to apply my mathematical knowledge.	science	26	42	24	8
	non-science	18	47	26	10

Cheating behaviour		SA	PA	PD	SD
S42. I sometimes copy answers from other students during tests.	science	7	16	22	55
	non-science	9	27	21	44
S43. I sometimes cheat while doing my class work.	science	7	17	20	55
	non-science	8	25	23	44
S62. I sometimes copy answers from other students when I do my homework.	science	3	19	28	50
	non-science	7	27	30	40

Student competence		SA	PA	PD	SD
S24. Mathematics was my worst subject in high school.	science	6	11	13	71
	non-science	10	13	17	60
S25. Mathematics is hard for me.	science	13	48	25	14
	non-science	23	42	22	13
S46. I am good at mathematics.	science	6	44	36	14
	non-science	5	37	36	23
S47. I think that what I am learning in mathematics is interesting.	science	25	50	20	5
	non-science	18	46	25	11
S48. Compared with others in the class, I think I am good at mathematics.	science	6	39	41	14
	non-science	6	37	38	19
S55. I understand everything we have done in mathematics this year.	science	14	33	34	20
	non-science	11	34	34	21

Teacher role		SA	PA	PD	SD
S37. My lecturer explains why mathematics is important.	science	3	27	42	29
	non-science	5	23	42	30
S53. The lecturer has not been able to explain the processes we were studying.	science	3	20	39	38
	non-science	5	24	37	33
S54. My lecturer has not inspired me to study mathematics.	science	12	32	34	22
	non-science	14	32	34	20
S60. My lecturer tries to make mathematics lessons interesting.	science	10	32	37	20
	non-science	10	28	40	23
S68. In addition to mathematics, the lecturer teaches us how to study.	science	3	19	31	47
	non-science	4	16	33	47

Appendix B

Gender comparison

Performance-approach goal orientation		SA	PA	PD	SD
S15. It is important to me that other students in my class think I am good at my class work.	male	16	48	17	19
	female	20	52	17	11
S16. One of my goals is to show others that I am good at my class work.	male	8	34	27	31
	female	10	36	28	27
S26. One of my goals is to show others that class work is easy for me.	male	1	15	33	51
	female	2	13	32	54
S27. It is important to me that I look intelligent compared to others in my class.	male	2	8	23	67
	female	1	5	17	77

Relevance		SA	PA	PD	SD
S22. Some knowledge of mathematics helps me to understand other subjects.	male	43	43	12	2
	female	45	43	9	3
S28. Knowing mathematics will help me earn a living.	male	14	44	22	20
	female	18	46	19	17
S29. I think mathematics is an important subject.	male	53	39	7	2
	female	61	32	5	1
S34. Studying mathematics is a waste of time.	male	15	53	24	8
	female	10	50	33	7
S49. I can use what I learn in mathematics in other subjects.	male	24	50	19	7
	female	22	51	20	7
S59. I study mathematics because I know how useful it is.	male	30	47	19	4
	female	41	45	11	2
S69. Mathematics enables us to better understand the world we live in.	male	33	41	19	7
	female	37	47	12	5
S73. I can apply my knowledge of mathematics to everyday life.	male	15	52	25	8
	female	18	51	27	5

Mastery goal orientation		SA	PA	PD	SD
S17. It is important to me that I improve my skills this year in mathematics.	male	30	45	16	9
	female	37	44	14	5
S52. I am very motivated to study mathematics.	male	12	39	34	15
	female	23	41	27	9
S64. It is important to me that I thoroughly understand my class work.	male	37	47	14	2
	female	51	43	7	0
S65. It is important to me that I learn a lot of new mathematical concepts this year.	male	16	43	33	9
	female	20	47	26	8
S71. One of my goals is to master a lot of new skills this year.	male	16	44	31	9
	female	21	49	24	7
S78. One of my goals in class is to learn as much as I can.	male	28	47	20	5
	female	39	46	12	3

Personal value of mathematics		SA	PA	PD	SD
S23. A knowledge of mathematics is important; it helps us to understand the world.	male	20	54	20	6
	female	28	56	13	3
S30. Mathematics is useful for our society.	male	35	39	20	7
	female	37	42	18	4
S74. After graduating university I have many opportunities to apply my mathematical knowledge.	male	20	42	29	10
	female	25	47	21	7

Cheating behaviour		SA	PA	PD	SD
S42. I sometimes copy answers from other students during tests.	male	11	26	21	42
	female	4	17	21	58
S43. I sometimes cheat while doing my class work.	male	11	24	23	41
	female	4	17	20	59
S62. I sometimes copy answers from other students when I do my homework.	male	6	25	29	40
	female	3	20	26	51

Student competence		SA	PA	PD	SD
S24. Mathematics was my worst subject in high school.	male	8	13	16	63
	female	8	11	14	68
S25. Mathematics is hard for me.	male	20	45	23	11
	female	16	45	24	16
S46. I am good at mathematics.	male	4	37	40	19
	female	7	45	31	17
S47. I think that what I am learning in mathematics is interesting.	male	17	47	27	9
	female	27	49	18	7
S48. Compared with others in the class, I think I am good at mathematics.	male	7	35	43	15
	female	5	41	36	18
S55. I understand everything we have done in mathematics this year.	male	10	32	36	22
	female	14	35	32	19

Teacher role		SA	PA	PD	SD
S37. My lecturer explains why mathematics is important.	male	3	25	40	31
	female	5	25	43	28
S53. The lecturer has not been able to explain the processes we were studying.	male	5	24	38	33
	female	3	20	39	39
S54. My lecturer has not inspired me to study mathematics.	male	16	36	31	18
	female	10	27	38	25
S60. My lecturer tries to make mathematics lessons interesting.	male	10	25	41	24
	female	10	35	35	20
S68. In addition to mathematics, the lecturer teaches us how to study.	male	3	19	34	44
	female	3	16	30	51

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