Serbian Students' Attitudes towards Mathematics and Mathematical Education

Tempus Attitude Survey (TAS) 2013–2014 Report

Kristóf Fenyvesi – Raine Koskimaa – Ruth Mateus-Berr – Ljiljana Radovic – Djurdjica Takaci – Suncica Zdravkovic – Klelija Zivkovic

UNIVERSITY OF JYVÄSKYLÄ

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by

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Abstract

Kristóf Fenyvesi, Raine Koskimaa, Ruth Mateus-Berr, Ljiljana Radovic, Djurdjica Takaci, Suncica Zdravkovic, Klelija Zivkovic

Serbian Students' Attitudes towards Mathematics and Mathematical Education
Tempus Attitude Survey (TAS) 2013–2014 Report Program

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During 2013-2014, the team of the Tempus project "Visuality & Mathematics: Experiential Education of Mathematics through Visual Arts, Sciences and Playful Activities", No. 530394-TEMPUS-1-2012-1-HU-TEMPUS-JPHES conducted 3 rounds of attitude surveys.

The first large survey commenced in 2013 and the second, in 2014. Both explored the attitude of Serbian students towards mathematics in general and towards the education of mathematics. Based on the first round of survey results, we provided special training for teachers in experiential education of mathematics and asked them to utilize our methods for a full academic year in their schools, and then we conducted the second large survey to assess the effects of the new teaching techniques. Another short survey was conducted, investigating the success of the Summer Schools organized within the framework of our Tempus project. All results were used to make specific recommendations for the future development of the mathematics curriculum in Serbian education of mathematics at all levels.

Keywords: mathematics, education, attitudes, Serbia

Chapter 1

Introduction

The *Visuality & Mathematics – Experiential Education of Mathematics Through the Use of Visual Art, Science, and Playful Activities* Tempus Project was launched with the cooperation of eight European universities and scientific institutions[1], in order to develop Serbian mathematics education with technological equipment and interactive, experience-centred, and arts and design-related contents.[2] The general objectives of this two-year-long project were justified by the findings of the PISA 2012 study[3] showing that 15-year old Serbian students' mathematics performance was significantly below the OECD average. If the goal is the improvement of Serbian students' mathematical literacy, then research into new approaches to the teaching of mathematics needs to be conducted. There also needs to be an increase in experience-centred approaches of mathematics teaching in the schools, reflecting the cultural, interdisciplinary and artistic embeddedness of mathematics, with a major focus on the creative and artistic applications of hands-on models, digital technology and real-life problems.

In this project, we were not only developing genuinely new content and methods in Serbian mathematics education, but also collecting pre-existing practices of experience-centred mathematics education, teaching resources and tools in Serbia. Our findings were made available on the project website (http://vismath.ektf.hu/) and in our publications, to allow them to be widely disseminated to Serbian mathematics teachers and introduced in teacher training. For this purpose also, we organized *European Summer Schools for Visual Mathematics and Education* in Eger, Hungary in 2013[4] and in Belgrade, Serbia in 2014[5]. The Summer Schools offered opportunities to train Serbian mathematics teachers and university students and also to invite leading experts of experience-centred mathematics education from all over the world. The target audience of our Summer Schools were mainly undergraduate students, practicing teachers of mathematics and other subjects, and

[1] Project Leader: Eszterházy Károly College, Hungary. Project members: University of Jyväskylä (Finland), Sint-Lucas School of Architecture (Belgium), University of Applied Arts Vienna (Austria), Belgrade Metropolitan University (Serbia), University of Novi Sad (Serbia), Serbian Academy of Sciences and Arts (Serbia), ICT College of Vocational Studies (Serbia).

[2] Project website: http://vismath.ektf.hu/

[3] *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013).

[4] See: http://vismath.ektf.hu/index.php?l=en&m=233&ss=1

[5] See: http://vismath.ektf.hu/index.php?l=en&m=233

mathematicians and artists and designers interested in mathematics education. In the Summer Schools we largely focused on the questions: (1) how to integrate artistic and cultural contents and experience-centered, playful methods into mathematics teaching programs; (2) how to integrate experience-centered mathematics education into art teaching programs; (3) how to expand the set of tools used for developing a learner's perceptions and aesthetic sensibility while increasing mathematical, logical, combinatorial and spatial abilities, systems thinking to motivate collaborative problem solving, interdisciplinary and inter-artistic approaches in mathematics education; (4) and how to organize various kind of art&science communication events like math-art exhibits or festivals in Serbian schools. We managed to gather workshop materials, course plans and other assorted material from teachers and students from all around Europe on methods of instruction linking mathematics with the arts. In addition, we discussed interesting educational approaches and different ways of connecting mathematical and visual art contents in math and arts education.

The program of Summer Schools in Eger and Belgrade offered various lectures, seminars, workshops, presentations of educational software, discussion groups for teachers focusing on developments in the fields of experience-centered education of mathematics through arts, sciences and playful activities and arts education through the experience-centered approach to mathematics. The program also included a Family Day, where the local population were invited to participate in various mathematics and arts programs of the Summer Schools.

Chapter 2

Mathematics Learning in the Serbian Education System

2.1 Education in Serbia

Education in Serbia is supervised by the Ministry of Education, Science and Technological Development of the Republic of Serbia. In Serbia, compulsory education is regulated by the law of "basic systems of schooling and education" ("Zakon o osnovama sistema obrazovanja i vaspitanja"). In the framework of ISCED it can be described as follows:

1. *Code Level ISCED 0:* Pre-primary education
   Early childhood education is divided into two stages:

   - First stage: optional, no duration criteria, minimum age: 6 months, upper age limit is 6 years.
   - Second stage: compulsory, pre-school programme, duration 1 year, age 6-7 years.

2. *Code Level ISCED 1:* Primary education, first stage of basic education, compulsory, 4 year duration, organized as class teaching.

3. *Code Level ISCED 2:* Lower secondary education (second stage of basic education), compulsory, 4 year duration, organized as subject teaching.

4. *Code Level ISCED 3:* Upper secondary education, optional, 3-4 year duration.

5. *Code Level ISCED 4:* Post-secondary, non-tertiary education, optional, (Više škole), 3 year duration.

6. *Level ISCED 5:* First stage of tertiary education, Bachelor 3-4 years' duration, and master studies, 1 or 2 years duration.

7. *Level ISCED 6:* Second stage of tertiary education, PhD studies, 3 years duration.

In the second stage of basic education (11-15 years old students) the students have 4 lesson hours for mathematics per week (144 per year) in the first three grades, and 128 in the final year.

In Serbia, there are two types of secondary schools: gymnasiums (4 years) and vocational schools (3 or 4 years). Mathematics is a compulsory subject in all primary and secondary schools. The different profiles of secondary schools together with the distribution of lessons for mathematics are presented below:

1. In Gymnasium, students have 4 mathematics lessons per week (144 lessons per year) in the first three grades and 128 lessons in the fourth year.

2. In mechanical and electrical engineering profile vocational schools, 3 years duration, students have 3 lessons for mathematics per week (111 lessons per year), during the first two grades, and in the third grade they have 2 mathematics lessons per week (64 lessons per year).

3. In mechanical and electrical engineering profiles, students have 4 lesson hours for mathematics per week in all four grades (148 per year in the first and second year, 140 in the third and 124 in the fourth year).

4. In agriculture and food production and processing profiles, 3 years duration, students have 3, and 2 lesson hours for mathematics per week (105, 70 per year), respectively, in the first two grades.

5. In agriculture and food production and processing profiles, students have 4 lesson hours for mathematics per week in first two grades, (148 per year in the first and 140 in the second year). In the final two grades students have 3 lesson hours for mathematics per week (105, 90 per year, respectively).

6. In other technical profiles, 3 years duration, students have 3 lesson hours for mathematics per week (111, 105 per year, respectively) in the first two grades, and 2 lesson hours for mathematics per week (64 per year) in the third grade.

7. In other technical profiles, students have 4 lesson hours for mathematics, per week (148, 140, per year, respectively), in the first two grades, and 3 lesson hours for mathematics per week (105, 90, per year, respectively) in the last two grades.

8. In trade and catering profiles, 3 years duration, students have 3 lesson hours for mathematics, per week (105 per year), in the first grade, and 2 lesson hours for mathematics, per week (64, 58 per year respectively) in the last two grades.

9. In economics and administration profiles, students have 3 lesson hours for mathematics per week in all grades, (105 per year in the first three years and 90 in the fourth).

In elementary and secondary schools a five-point grading scale is used: 5 (excellent), 4 (very good), 3 (good), 2 (sufficient) and 1 (insufficient).

At the end of primary school students have final exams where mathematics is one of three obligatory subjects. Based on the results of these exams students can enter various secondary schools.

At the end of secondary school students have final exams called "matura", but mathematics is not among the obligatory subjects. Students have to pass an entrance exam to gain enrolment to all universities. The results of "matura" are not taken into account for university entrance. Entrance to university is based on the results of the entrance exams (maximum 60 points) together with the results of students overall success (an average mark collated from secondary school studies, up to a maximum of 40 points).

Tertiary education in Serbia is arranged according to the Bologna process. There are:

- Higher schools (*viša škola*) lasting 3 years.
- Faculties (*fakultet*) of Universities (*univerzitet*) and art academies (*akademija umetnosti*) lasting 3-4 years for baccalaurean, plus 1-2 years for masters, plus 3 years for PHD.

At universities and higher schools a six-point grading scale is used: 10 (excellent – outstanding) for 95-100 points, 9 (excellent) for 85-94 points, 8 (very good) for 75-84 points, 7 (good) for 65-74 points, 6 (sufficient, pass) for 55-64 points, and 5 (not sufficient, fail).

Mathematics courses are taught at almost all universities.

Secondary school teachers are educated at Faculties of Sciences (Departments of Mathematics) or Faculties of Mathematics. Besides mathematics content, students have obligatory pedagogy, didactics and psychology classes, as well as teaching practice in schools.

All subjects are taught in the Serbian language or (and) in the language of ethnic minorities.

Less than 1% of schools are private (all levels of education) in Serbia.

All academic institutions and programs are required to be accredited by the Government Accreditation Committee.

Education in Serbia faces various challenges: scientific, humanistic, social, developmental and, in particular, rapid and great technological changes. The main objective of the education system in Serbia is to address such challenges. The main challenge in Serbian education is the adoption of European standards and access to the common European education system.

The Ministry of Education in Serbia is working hard on improving and updating the entire educational system. The Institute for the Advancement of Education (Zavod za unapredjivanje vaspitanja i obrazovanja) has been monitoring, securing and improving the quality and development of the education system since 2004.[1]

Teachers, together with school authorities, are making great efforts to provide new equipment in computer laboratories for students in all schools. Universities are usually well-equipped with computers, projectors, and other technologies necessary for applying state-of-the-art technology-based methods for their teaching. Many elementary and high schools are already well-equipped with IT devices, but there are still a lot of schools without such equipment. Nevertheless, the number of teachers

[1] See: http://www.zuov.gov.rs/novisajt2012/index.html

using new technology is increasing year on year at all levels.[2] Elementary and high school teachers receive compulsory training in computer-assisted teaching at seminars accredited by the Institute for the Advancement of Education (Zavod za unapredjivanje vaspitanja i obrazvanja). There are teachers open to adopting new methodologies involving technology, but they are usually in the minority.

The "Visuality & Mathematics" Tempus project was established in order to address all these issues and was targeted at Serbian teachers and university students in teacher education. The Summer Schools organized in 2013 in Eger and in Belgrade in 2014 were accredited; meaning the educational institutions of the Serbian government recognized the significance of the project's contribution to teacher education.

It is important to note that although mathematics is represented in almost all secondary school curricula in Serbia, the result of Serbian students in PISA 2012 (with 449 points) is not satisfactory. Therefore much research and analysis of the results has been conducted by the educational institutions of the Serbian government in order to attempt to overcome the students' difficulties. Specific emphasis has been put on developing mathematical modeling and presenting mathematics in real-world situations in the school curricula, as has the development of computer-assisted mathematics learning. The main objectives of the "Visuality & Mathematics" Tempus project are in line with governmental policies.

2.2 Mathematics Education in Serbia from the Perspective of the PISA 2012 Results

PISA 2012 reveals that although Serbia – which scored 449 points – steadily improved in mathematics education from 2003,[3] the mathematics performance of 15-year old Serbian students is still statistically significantly below the OECD average. According to PISA's definition of mathematical literacy[4], Serbian students fall behind the OECD average in their capacity to formulate, employ, and interpret mathematics in various contexts, and also have difficulty recognizing the role that mathematics plays in the world. From the four overarching areas, which the PISA assessment framework for mathematical literacy makes reference to, it is only in *quantity* that the Serbian students score higher than their overall mathematics proficiency scale. Operations in the other three areas of mathematical literacy, i.e.

[2]See: Natalija Budinski, A Survey On Use Of Computers In Mathematical Education In Serbia, The Teaching of Mathematics, (2013), Vol. XVI, 1, pp. 42–46;
Jovana Jezdimirović, Computer Based Support For Mathematics Education In Serbia, International Journal of Technology and Inclusive Education (IJTIE), Volume 3, Issue 1, June 2014. Progress is also represented by reports in daily newspapers, see: Trećina Srbije nije koristila računar i internet! Source: http://mondo.rs/a730090/Mob-IT/Vesti/Trecina-Srbije-nije-koristila-racunar-i-internet.html [Retrieved: 28.9.2014];
Bringing computer literacy and innovative teaching to Serbia. Republic of Serbia Education Improvement Project. Source: http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22616044~menuPK:141310~pagePK:34370~piPK:34424~theSitePK:4607,00.html [Retrieved: 28.9.2014].

[3]*PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 55.

[4]*PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 37–38.

(1) *uncertainty and data*, (2) *change and relationships*[5], and (3) *space and shape*[6], cause even more difficulties for them.

PISA 2012 not only measured students' performances, but also examined how their exposure to mathematics content can be associated with their performance. This provides a snapshot of the priorities of Serbian mathematics education policies. The survey has shown that Serbian students' exposure to word problems is under the OECD average[7], as is their exposure to applied mathematics[8], yet they have significantly more opportunities to learn formal mathematics content during their schooling.[9]

The examination of Serbian students' engagement, drive, and self-beliefs in connection with mathematics learning shows that the index of their mathematics self-efficacy – the extent to which they believe in their own ability to handle mathematical tasks effectively and overcome difficulties – is also relatively low, while their index of openness to problem solving is high, although the latter is not reflected in their mathematics performance[10]. Serbian students' intrinsic motivation to learn mathematics is slightly lower than the average as well, but from the survey results it is also obvious that the educational system is not taking full advantage of their positive attitudes and their openness to problem solving. In Serbia, less than 30% of students enjoy mathematics.[11]

The picture provided by PISA 2012 on Serbian students' mathematics education and attitudes is further refined by our Tempus Attitude Survey from 2013. We succeeded in identifying a number of pedagogical practices applied to mathematics education of 11–18 year old Serbian students, for which we recommend changes in order to improve and build more efficiently on students' attitudes towards mathematics and thus support them in achieving better results.

[5] *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 101.

[6] *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 104.

[7] *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 147.

[8] *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 149.

[9] *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science.* (Vol. I), PISA, OECD Publishing (2013), 148.

[10] *PISA 2012 Results: Ready to Learn – Students' Engagement, Drive and Self-Beliefs* (Vol. III), PISA, OECD Publishing (2013), 11.

[11] *PISA 2012 Results: Ready to Learn – Students' Engagement, Drive and Self-Beliefs* (Vol. III), PISA, OECD Publishing (2013), 69.

Chapter 3

Tempus Attitude Survey 2013

Interest in the role of affect in science learning grew in the 1960-70s when education policy-makers were faced with falling enrolment in science in higher education[1]. In researching the reasons for the decreasing number of science students, in the 1960-70s mathematics education research on affect two different foci were apparent: 'mathematics anxiety', and 'attitude toward mathematics' (ATM). Studies of attitude are based on two beliefs: attitude toward mathematics is related to achievement, and affective outcomes (such as liking mathematics) are significant *per se*.[2]

Attitude in social psychological research is a"psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavor".[3] Attitudes strongly influence behavior and involve elements of knowledge and affects, and have a strong impact on education processes as well. Poor attitude towards the sciences are often caused by the way sciences are presented at school stages[4]. As research points out, this is not usually the fault of teachers but arises from bad curriculum design, overloaded curricula, and inappropriate assessment. Although attitudes tend to show consistency and are relatively stable, they are open to change and development, given the right circumstances.[5]

The abstractness of mathematics as science makes it a unique discipline often perceived as exterior to the contexts of daily life. As numerous studies[6] demonstrate, this exteriority or detachment has also aroused negative attitudes among students toward mathematics and mathematical-scientific ways of thought as such. This widening gap between mathematics and students (and society at large) and

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[1]Ormerod, M. B. & Duckworth, D. (1975). *Pupils' attitudes to science: A review of research.* Windsor: NFER.

[2]Zan, Rosetta, Laurinda Brown, Jeff Evans, and Markku S. Hannula. *"Affect in Mathematics Education: An Introduction."* Educational Studies in Mathematics 63, no. 2 (October 1, 2006): 113–21. doi:10.1007/s10649-006-9028-2.

[3]A.H. Eagly & S. Chaiken, *The psychology of attitudes.* Fort Worth, TX: Harcourt, Brace, & Janovich, 1993.

[4]Skryabina, E. (2000). *Students' attitudes to learning physics at school and university level in Scotland.* PhD thesis, University of Glasgow, Glasgow.

[5]Saleh, Issa M., and Myint Swe Khine. *Attitude Research in Science Education: Classic and Contemporary Measurements.* IAP, 2011.

[6]Cf. Malmivuori, M.-L. (2001), *The dynamics of affect, cognition, and social environment in the regulation of personal learning processes.* The case of mathematics, Academic Dissertation, University of Helsinki, Helsinki.

its paradox nature holds innumerable dangers and was recognized decades ago,[7] but is still growing as the recent PISA 2012 assessment has demonstrated and as has TIMSS 2011 which mapped the close ties between attitudes and achievement in mathematics learning. As attitude-research shows, students tend to sustain an aversion to mathematics[8] and even display *"math-anxiety"*[9], while remaining largely ignorant of how deeply embedded it is in the world around them[10]. Moreover, mathematics has traditionally been regarded as a male domain, which led to gender bias in mathematics performance in education and is known to be a significant part of the issues connected to math anxiety.

Most students however are able to recognize patterns and deal fluently with the abstractions of language, music, arts and design. Numerous research evidence and empirical evidence indicates that people become easily motivated and even fascinated when mathematical connections are presented in ways which relate to their experiences by triggering their natural curiosities and aesthetic sensibilities. There has already been significant research done by mathematicians, historians, educators, and practicing artists in the exploration of mathematical connections between the arts, sciences, music, culture, architecture and design.[11] Exponentially expanding interdisciplinary fields of research like visual mathematics, ethno-mathematics, symmetry studies, computer-aided design, systems design and studies of experiential and inquiry-based learning of mathematics, have accumulated an enormous body of results during the last decades. Geometric and mathematical art, from Paleolithic

[7]The Mathematics in Society Project (MISP) began in 1980 as an international association of mathematics educators. They realised there was a paradox in that mathematics is widely used and diffused implicitly in all industrialized societies, but most pupils find school mathematics difficult and/or unpleasant. Cf. Rogerson, A. (1986), MISP - A New Conception of Mathematics, International Journal of Mathematical Education in Science and Technology, 17. 5.

[8]Iben, M. (1991). Attitudes and mathematics. Comparative Education, 27 (2), 135-142.; Ma. X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. Journal for Research in Mathematics Education, 28 (1), 26-47.; Ruffell, M., Mason, J., & Allen, B. (1998). Studying attitude to mathematics. Educational Studies in Mathematics, 35, 1-18.; Gomez Chacon M. (2000). Affective influences in the knowledge of mathematics. Educational Studies in Mathematics, 43 (2), 149-168.; Hannula, M. (2002). Attitude towards mathematics: Emotions, expectations and values. Educational Studies in Mathematics, 49 (1), 25-46.; Uusimaki, L. S. (2004). Addressing preservice student teachers' negative beliefs and anxieties about mathematics. Thesis. Retrieved August 1, 2013 from: http://www.eprints.qut.edu.au/15921/.

[9]Curtain-Phillips, M. (1999), Math Attack: How to Reduce Math Anxiety in the Classroom, at Work and in Everyday Personal Use. Atlanta: Curtain-Phillips Publishing; Ashcraft, M. H. (2002), Math Anxiety: Personal, Educational, and Cognitive Consequences. Current Directions in Psychological Science Vol. 11, No. 5, 181-185.

[10]Hannula, M. The structure and dynamics of affect in mathematical thinking and learning. In M. Pytlak et al. (eds.). Proceedings of the Seventh Congress of the European Society for Research in Mathematics Education: Cerme 7, 9th - 13th February 2011, Rzeszów, Poland. 2011, pp. 34-60.; Hannula, M. Exploring new dimensions of mathematics-related affect: embodied and social theories. Research in Mathematics Education, 2012; Roesken, B., Hannula, M. S. & Pehkonen, E. (2011). Dimensions of students' views of themselves as learners of mathematics. ZDM 43 (4), 2011, 497-506.

[11]See the proceedings of the world's largest art and mathematics community, the Bridges Conferences in 16 volumes (www.archive.bridgesmathart.org); the numerous issues of the journal SYMMETRY: Culture and Science (http://symmetry.hu/aus_journal_content_abs.html); Issues of the Journal of Mathematics and the Arts (http://www.tandfonline.com/loi/tmaa20), etc.

ornaments to contemporary digital art and design[12] have produced substantial evidence of how deeply mathematical knowledge and systems approach is embedded in visual culture. However, this mathematical evidence unfortunately rarely appears in the school curricula. If it does, it rather appears on the periphery, as an interesting curiosity and not as a central topic or as a part of the core content of the mathematics classes.

In the Tempus Attitude Survey (TAS) we measured students' attitudes towards mathematics learning in Serbian education. Our intention was to study what specific aspects of Serbian students' mathematics learning experiences are perceived in a positive light and what are causing problems. TAS 2013 and TAS 2014 map the complex relationship between students mathematics anxiety, mathematics achievement in Serbia and the Serbian students' perception of the teaching methods applied in mathematics education in their school by their teachers. TAS questionnaires (see Appendix) explored several indicators related to Serbian students' drive and motivation and how these dispositions are associated with students' self-reported achievement in mathematics and whether they are related to gender and family background.[13] We were interested in the Serbian students' perception on the material and intangible resources that are invested by their education system, school, teachers and families to develop their study potentials.[14] We also tried to measure the Serbian students' intrinsic motivation to learn mathematics in order to see to what extent they find learning mathematics interesting and enjoyable. Students' enjoyment of mathematics learning is shaped by many factors.[15] In TAS we were most curious on how the perception of Serbian mathematics teachers' pedagogical and didactical approaches and actions and competence (in terms of making different contents, tools and facilities available in the learning process) are influencing students' attitudes and behavior. Our analysis attempted to identify some key factors in teaching practices in Serbian mathematics education which might undermine rather than foster students' intrinsic motivation for learning mathematics[16] and collected some recommendations for Serbian mathematics teachers, based on the research.

3.1 The Questionnaire and the Research Methods

The first survey was conducted in the spring of 2013. The main goal of this survey was to measure initial attitudes toward mathematics in general, but also toward mathematical education and in particular to mathematical education in Serbia.

Our sample consisted of two groups of students. The older group (age 19-50) was made up of university students of mathematics or neighbouring disciplines (i.e.

[12] Jablan S., Radovic L. (2011), Do you like paleolithic op-art?, Kybernetes, Vol. 40 7/8, 1045-1054.

[13] Cf. Ryan, R.M. and Deci, E.L. (2009), Promoting self-determined school engagement: Motivation, learning and well-being, in K.R. Wentzel and A. Wigfield (eds.), Handbook of Motivation at School, Taylor Francis, New York.

[14] Cf. Schiefele, U. (2009), Situational and individual interest, in K.R. Wentzel and A. Wigfield (eds.), Handbook of motivation at school, Routledge, New York/London.

[15] Cf. Dweck, C.S. (2006), Mindset, Random House, New York.

[16] Cf. Midgley, C., H. Feldlaufer and J.S.Eccles (1989), "Student/teacher relations and attitudes toward mathematics before and after the transition to junior high school", Child Development, 60, pp. 981-992.

computer science). We were particularly interested in the responses this group gave to the first part of the question: attitudes toward mathematics. These students were mostly good to very good in mathematics and some of them planned on becoming mathematics teachers themselves.

The other sample group came from 5 elementary and 15 high schools, consisting of children ranging in age from 11 to 18 years. They came from those schools, whose teachers' participated in our project and the Tempus Summer Schools.

The questionnaire used in the study was designed by the project team lead by a psychologist and a researcher of education. They proposed the initial set of indicators that should be investigated in order to meet the major goals of the survey.

The initial list indicators included wide areas such as:

- everyday approach to mathematics: usage, usefulness
- general ideas about mathematics
- general ideas about the education of mathematics
- students own experience with mathematics
- students own experience with mathematical education

Apart from general demographic data (age, sex, parents' education, rural/urban lifestyle) we gathered demographic data for particular purposes in this study. For example, we not only asked them what level of education their parents had, but also whether they had had an education that had a mathematical orientation (for example, whether they are engineers or lawyers). Also we asked them about their school grades and their grades in mathematics. Finally, we included a group of questions that scrutinized the habits of each participant in relation to mathematics learning and also their perception of the variety of teaching methods implemented in their mathematics education.

These indicators were discussed with the mathematicians, education specialists and art researchers in our project team. They helped in developing specific questions targeting different areas of teaching routines in mathematics.

The final version of the questionnaire consisted of 5 general demographic questions, 7 specific demographic questions and 41 survey questions. The English version of the questionnaire can be seen in the Appendix.

Given the sample size, sample selection and the variety of questions, we expected this research to produce an accurate picture in the domain of each initial indicator of the survey. As a measure of external reliability PISA 2012 results were used, produced prior to our survey (but with a wider focus).

3.2 Data Collection

The whole sample was surveyed in May 2013, at the very end of the school term.

Elementary and high school students, from all over Serbia, were tested in their own schools, during regular math classes. Therefore this testing did not require any special effort from the participants and they were able to take the questionnaire on mathematics in exactly the same space and time frame of a regular mathematics class.

The questionnaire with instructions was presented either by the school psychologist or one of the project members. It took students one school class (45 minutes) to complete.

University students were asked to take the online version of the same questionnaire. They had the last week of the school semester to finish the questionnaire, and it took them about 20 minutes.

3.2.1 Data Analysis

IBM SPSS Statistics 22.0.0.1 software was used in the analysis of the 2013 data. Data analysis included several sequential steps

- Control analysis
  - The first step was to insure the quality of collected data by running checks on interviewers and applied procedures
- Demographics
  - The next step included the analysis of sample size in general, and for elementary and high school sample size per school and per targeted teacher
- Main analysis
  - Analysis of responses concerning attitudes toward mathematics
- Refined analysis
  - Attitudes toward mathematics for particular groups, for example those with good grades, educated parents, etc.

3.3 Tempus Attitude Survey 2013: 11-18 Year Old Serbian Students

3.3.1 Demographical Information

2,607 11–18 year old Serbian students participated in the Tempus Attitude Survey 2013 (TAS 2013). From this age group 11–18 years, the survey which produced most responses was completed by 15-18 year old students. 29,9% of the 2,607 students were 17 years old, 25,3% 16 years old, 14,9% 15 years old and 14,3% 18 years old (Figure 3.1). 47,9% of the surveyed pupils were girls and 51,7% boys (Figure 3.2). 68,5% of the students interviewed live in cities and 30,9% in villages (Figure 3.3).

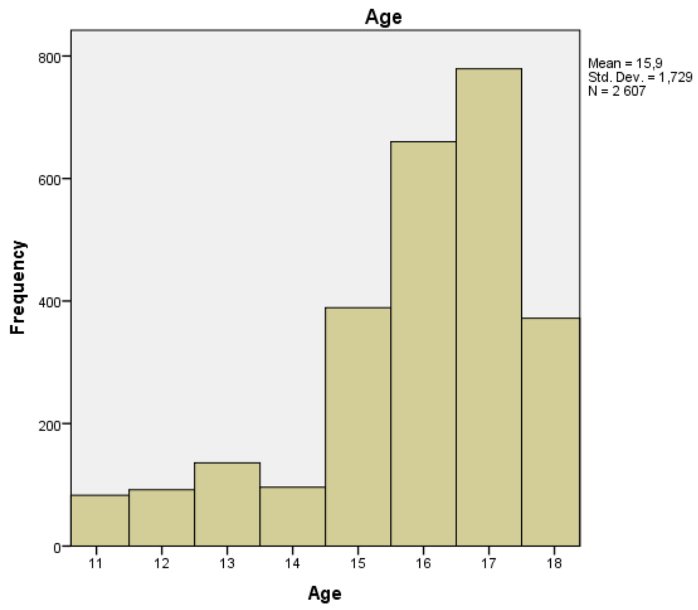


Figure 3.1

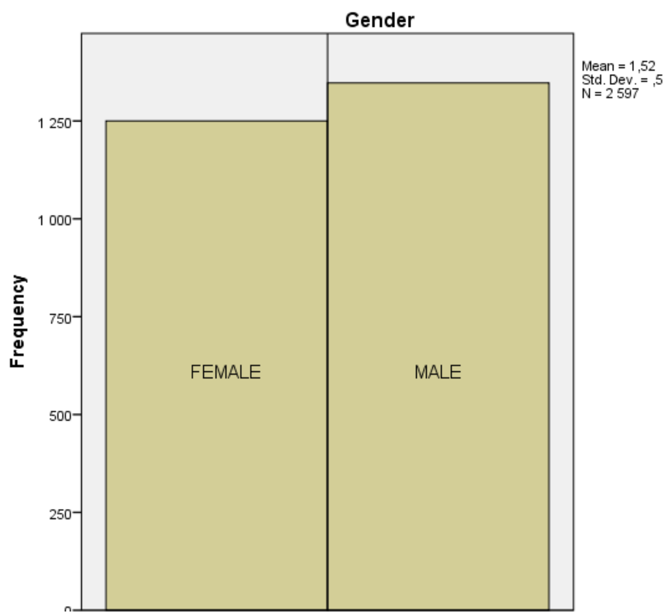


Figure 3.2

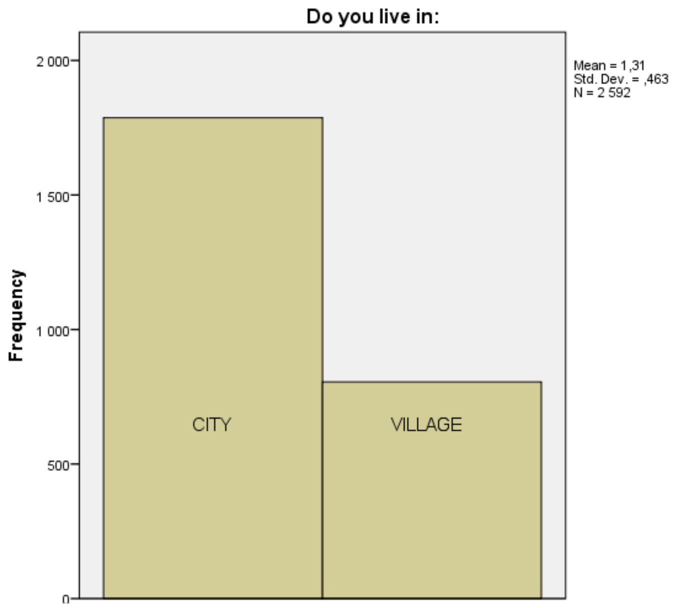


Figure 3.3

Regarding the highest level of education attainment of surveyed students' parents', one third of mothers had graduated from a higher education institution but the majority of mothers had only completed high school (56.1%) (Figure 3.4). In cases where their mothers' highest level of education attainment is university, graduation in law economics was the highest with 16,1%, and only 4,5% of the mothers graduated in mathematics or from a natural science program (Figure 3.5).

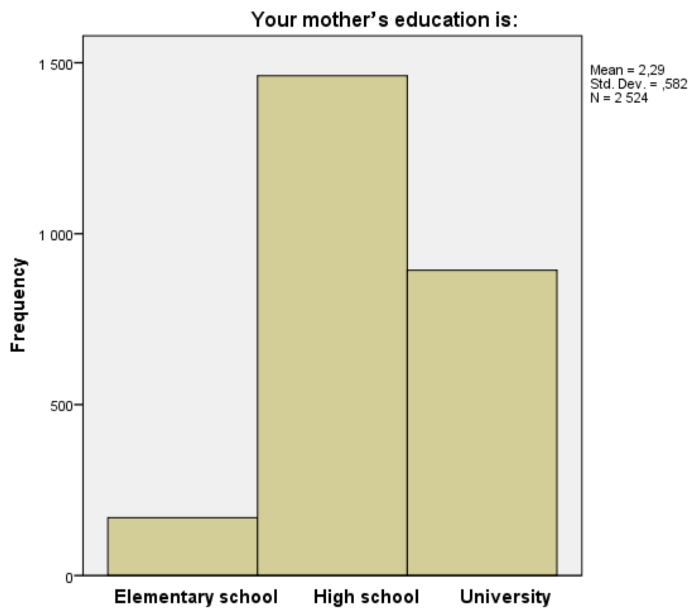


Figure 3.4

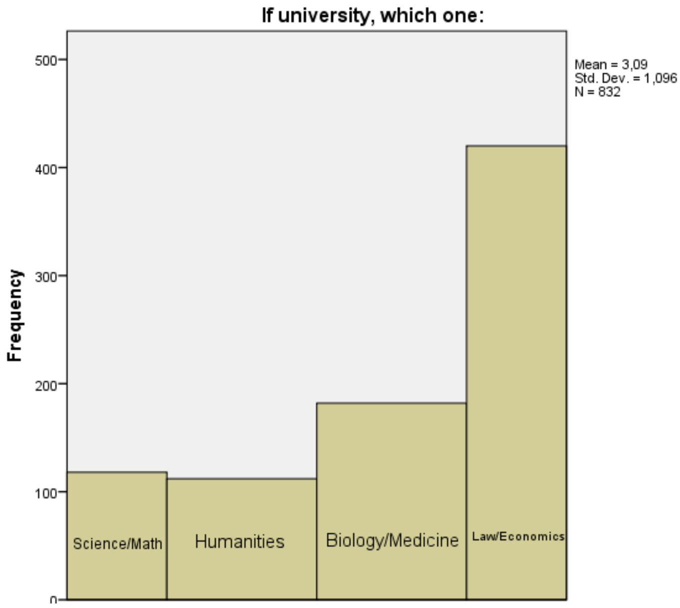


Figure 3.5

In the case of the fathers the proportions are similar. 31% of the respondents' fathers had a university education, and 59.2% of the fathers' highest education attainment is high school (Figure 3.6). Among the fathers who graduated from university, the highest percentage was in law or economics with 12%, but the proportion of mathematics and science graduates is higher among the fathers than the mothers, 6,1% (Figure 3.7).

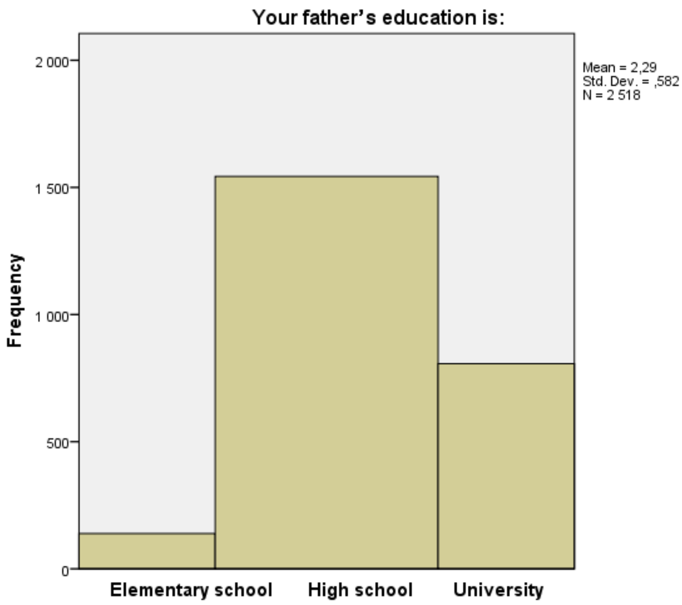


Figure 3.6

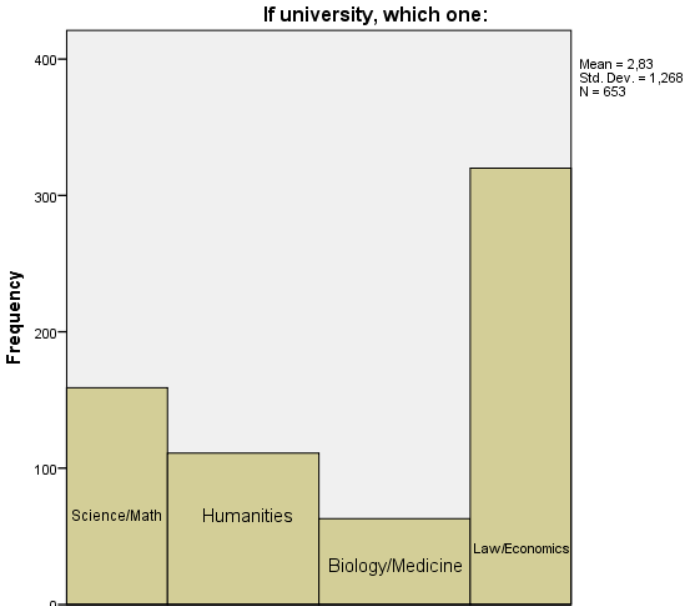


Figure 3.7

Regarding respondents' school grades, the students surveyed represent a balanced and average group with all grades (bar one, fail) more or less equally represented (Figure 3.8).

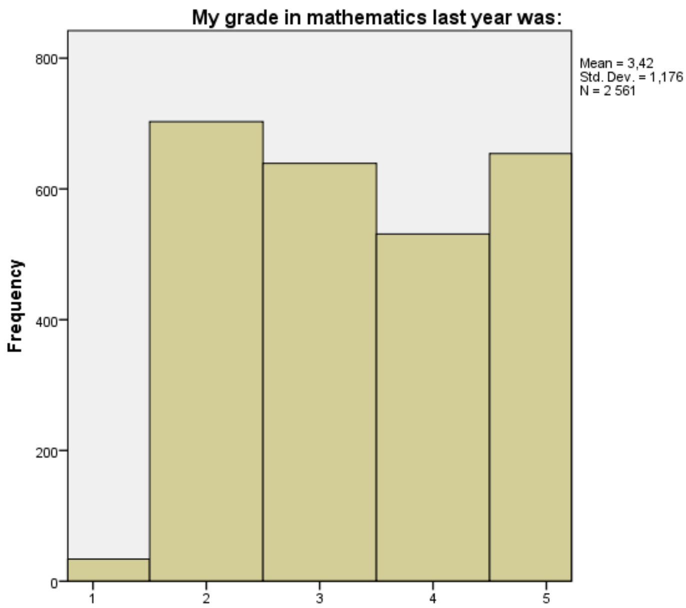


Figure 3.8

3.3.2 Views on the Role Mathematics Plays in Life and the Importance of Mathematics as a Subject in School for 11-18 year old Serbian Students

11-18 year old secondary and high school students attach great importance to mathematical knowledge. Most of them consider mathematics as essential to all people

(Figure 3.9) because they assume a close tie between mathematics and intelligence: a large majority of them agree with the statement that learning mathematics improves intelligence (Figure 3.10). They see mathematics not only as a school subject, but also as a field of knowledge, which they can implement beyond school in their everyday lives (Figure 3.11).

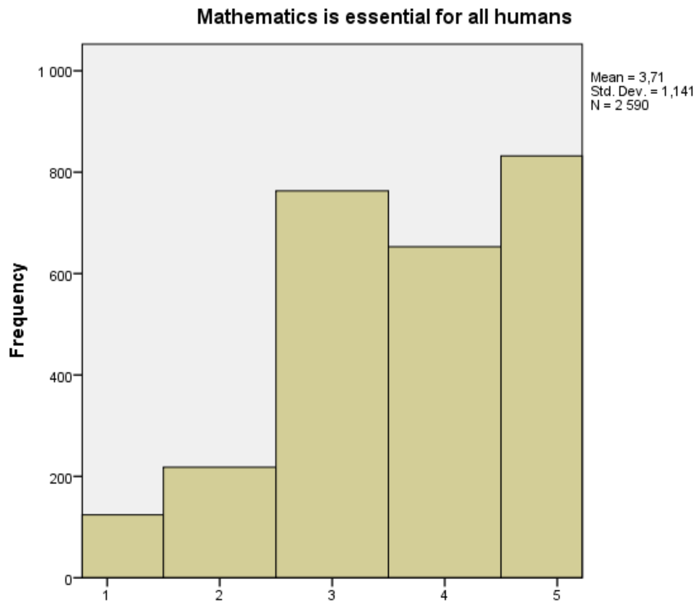


Figure 3.9: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

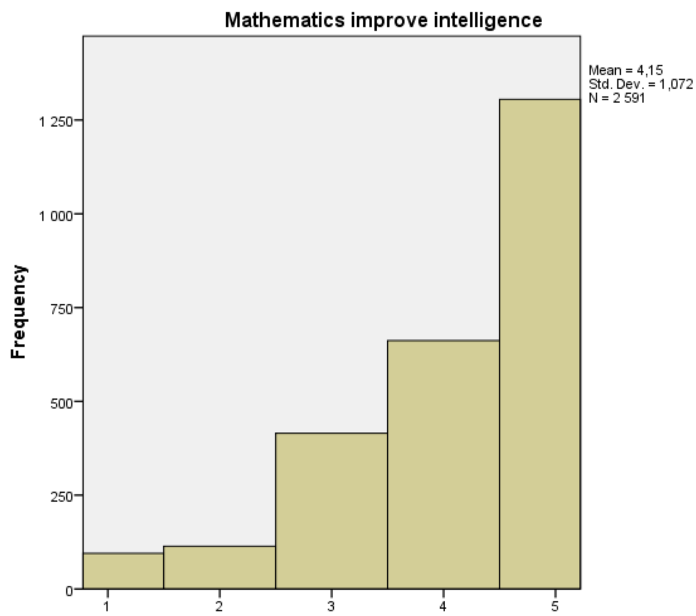


Figure 3.10: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

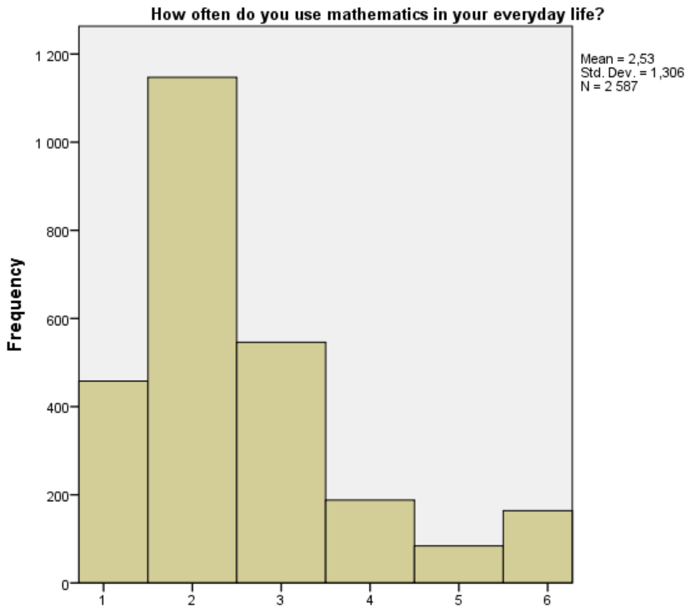


Figure 3.11: 1- A few times a day, 2- Every day, 3 Few times a week, 4- Every week, 5- Every month, 6- Less than once a month

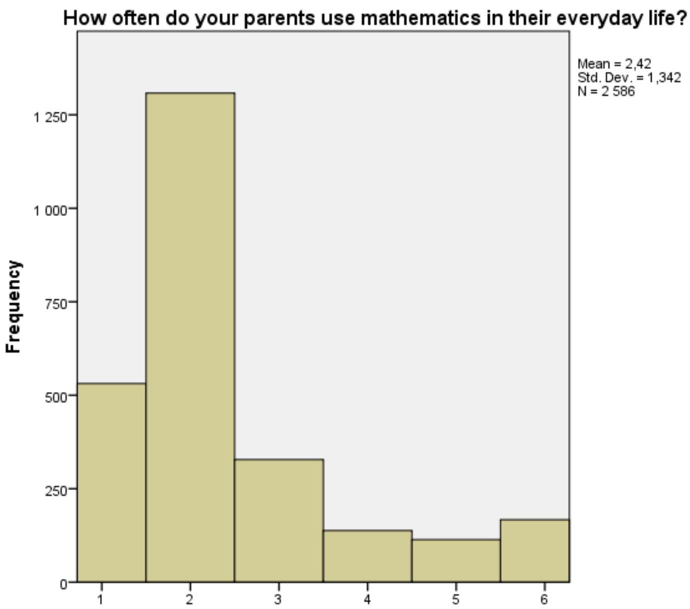


Figure 3.12: 1- A few times a day, 2- Every day, 3 Few times a week, 4- Every week, 5- Every month, 6- Less than once a month

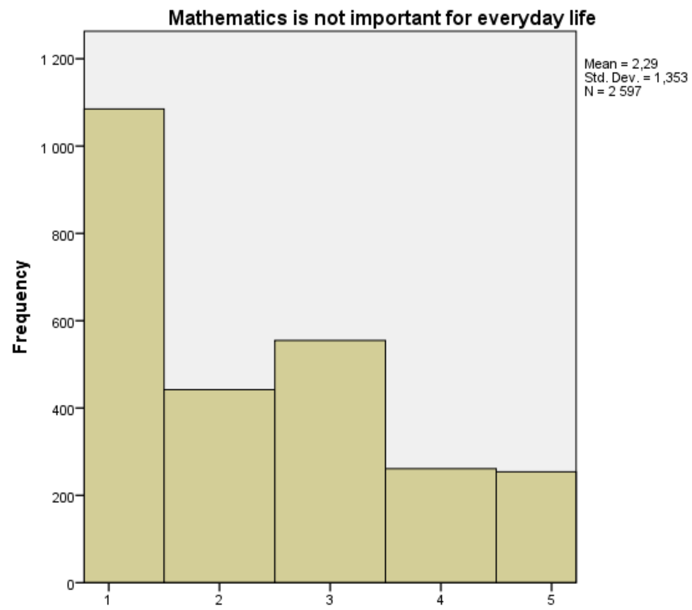


Figure 3.13: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

Mathematics plays an important role in students' life, and most of the students consider the acquisition of mathematical knowledge to a high level as something which leads to better career opportunities in the labour market (Figure 3.15).

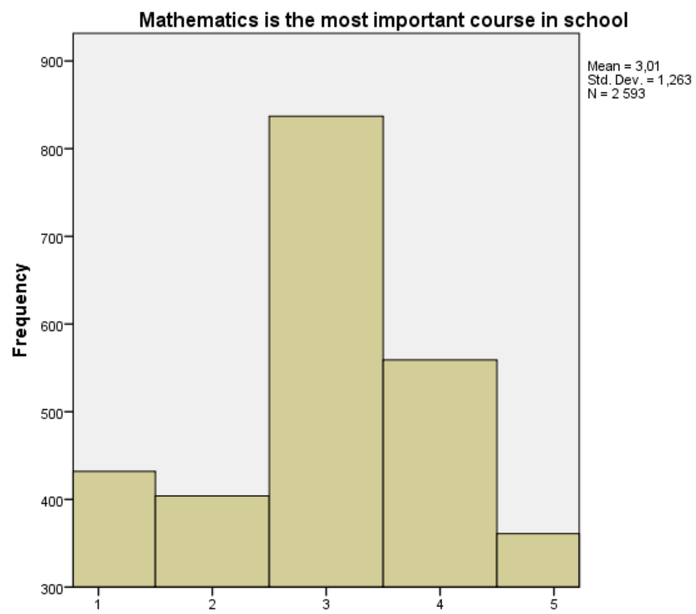


Figure 3.14: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

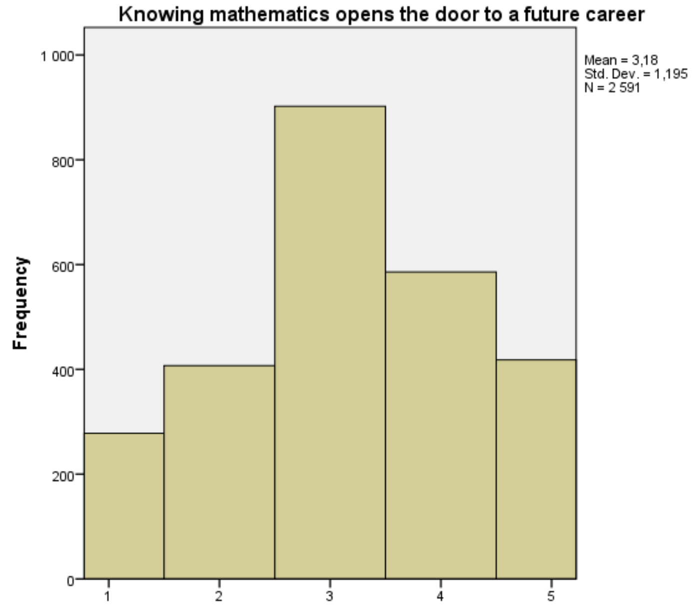


Figure 3.15: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

All these opinions are supported by the students' beliefs concerning their parents' expectations: without exception they think their parents attach a great deal of importance to their mathematical studies (Figure 3.16-3.17).

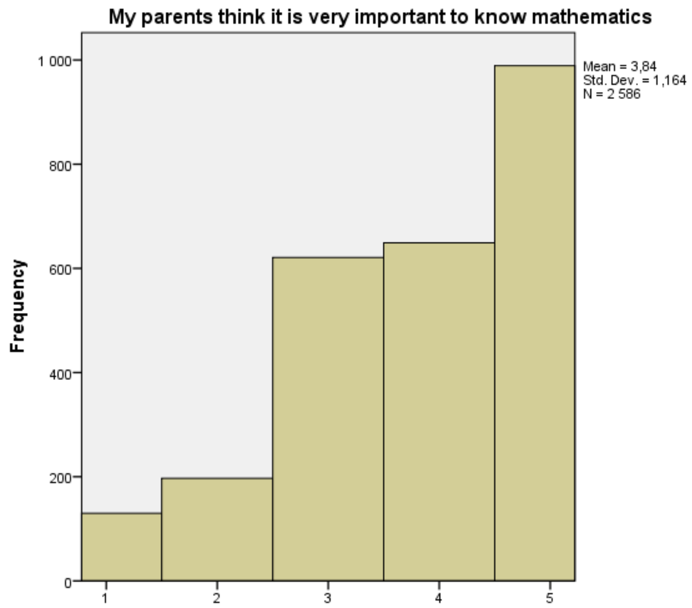


Figure 3.16: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

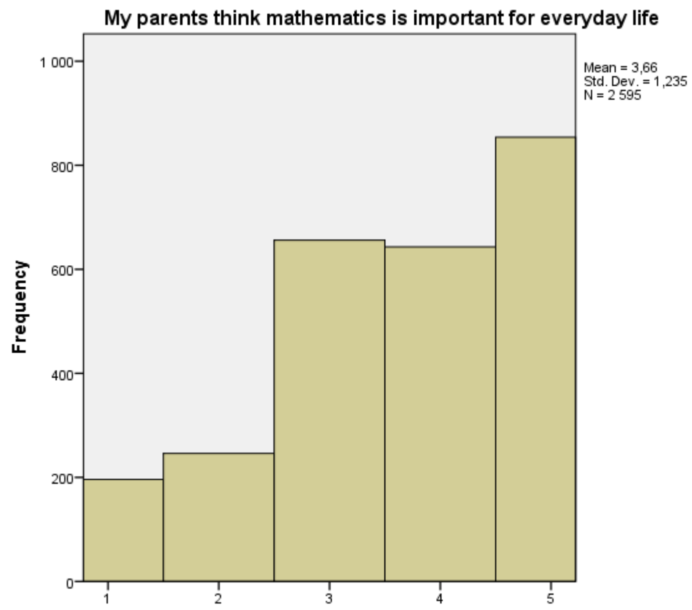


Figure 3.17: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

The students did not fully subscribe to the view that mathematics is the most important subject in school, but the majority did share this opinion (Figure 3.14). But there is full agreement on the assertion that the learning of mathematics is hard and difficult (Figure 3.18).

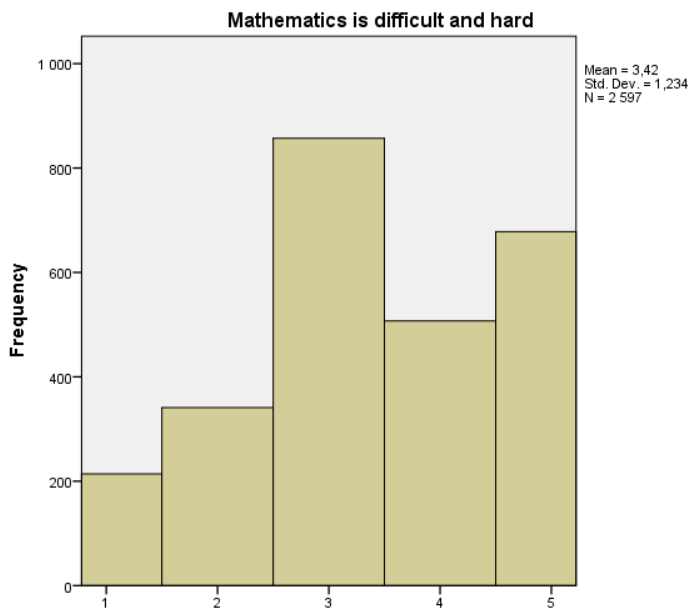


Figure 3.18: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

Accordingly, most of them pay a lot of attention to their mathematics education (Figure 3.19), and trust that their mathematics education in school prepares them for the mathematics required in their future lives (Figure 3.20).

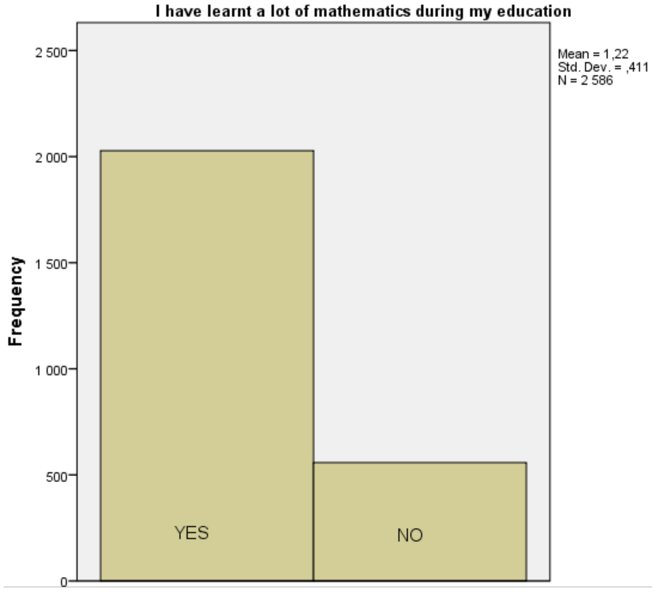


Figure 3.19

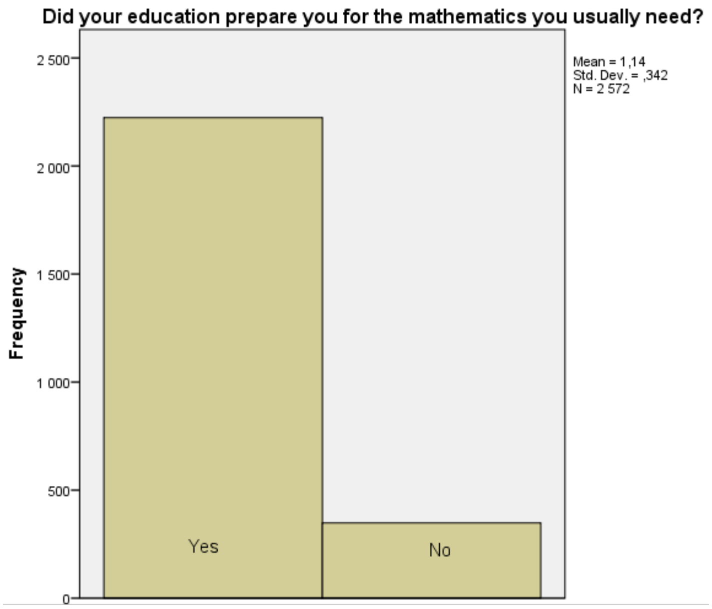


Figure 3.20

Most of them agree that mathematics learning would not be made easier by having more math classes in school: they think they already have enough (Figure 3.21). The problem is that the majority of the students do not feel personally addressed by the content of their mathematics classes: most of them feel mathematics classes are boring (Figure 3.22), and think that the content could be taught in a much more engaging way (Figure 3.23).

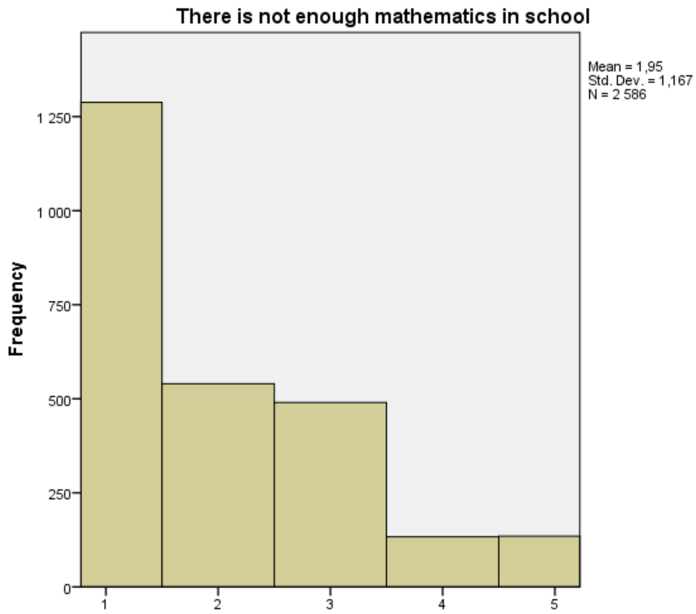


Figure 3.21: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

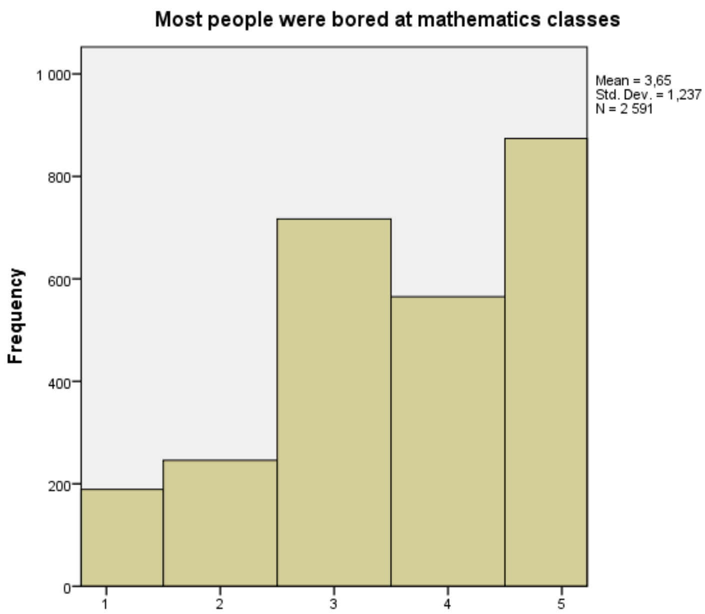


Figure 3.22: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

Nevertheless, the students apparently do not or do not dare link views on their disengagement from mathematics classes with their opinion about their teachers' performances. Most of the students are satisfied with their teachers or have a certain respect for them (Figure 3.23). Still, the majority agree that they would learn more mathematics, if the content of the classes were more interesting (Figure 3.24).

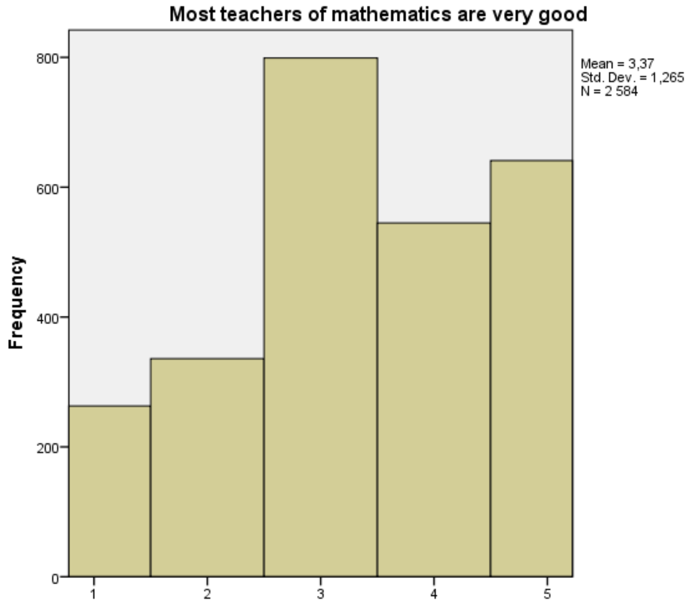


Figure 3.23: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

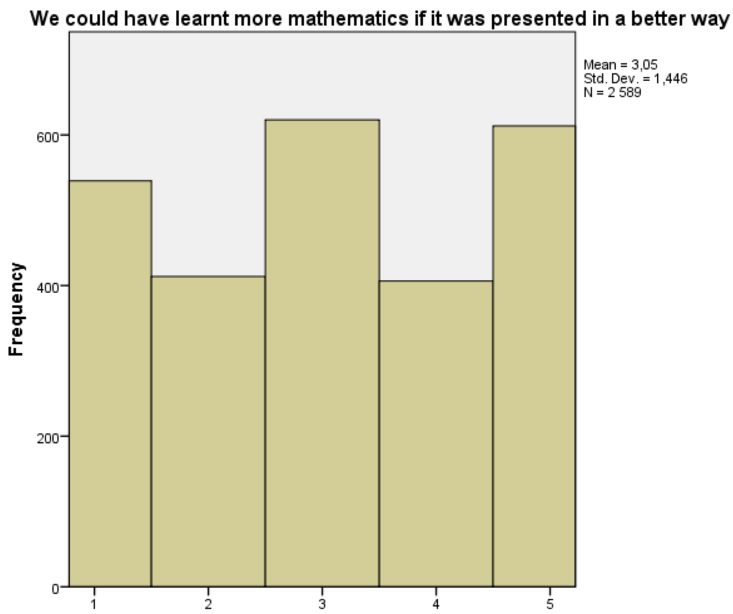


Figure 3.24: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

3.3.3 11-18 year old Serbian Students' Efforts and Challenges in Mathematics Learning

In order to do well at school, most of the students study mathematics at home on several occasions per week (Figure 3.25). Almost 50% spend 1-2 hours with their homework (Figure 3.26). Most of them face challenges in learning mathematics at home and some have had private mathematics lessons (Figure 3.27), but most have to deal with the challenges alone.

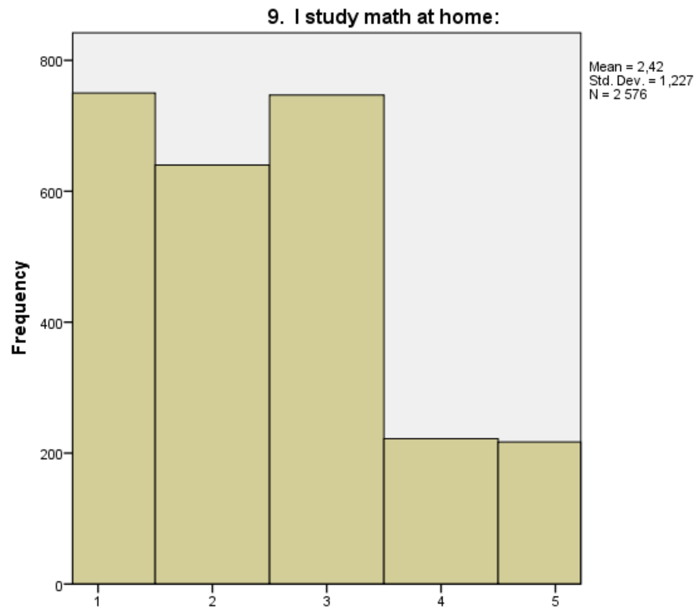


Figure 3.25: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

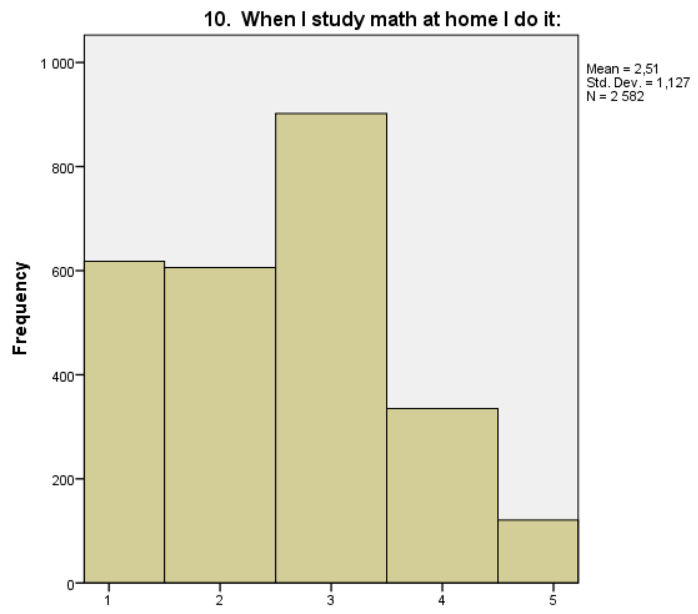


Figure 3.26: 1- About 15 minutes, 2- Less than an hour, 3- For about an hour, 4- For about two, 5- Longer than two hours

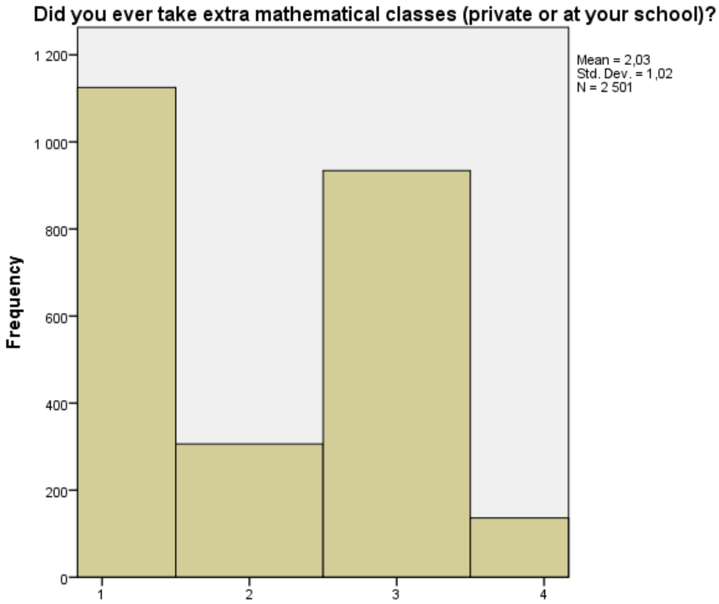


Figure 3.27: 1- NO, 2- YES, 3- A few times, 4- All the time

For the students it is more important to develop their mathematical knowledge (Figure 3.29) than to get better grades and they have a fundamental trust and respect towards the mathematical education in their school (Figure 3.28-3.31).

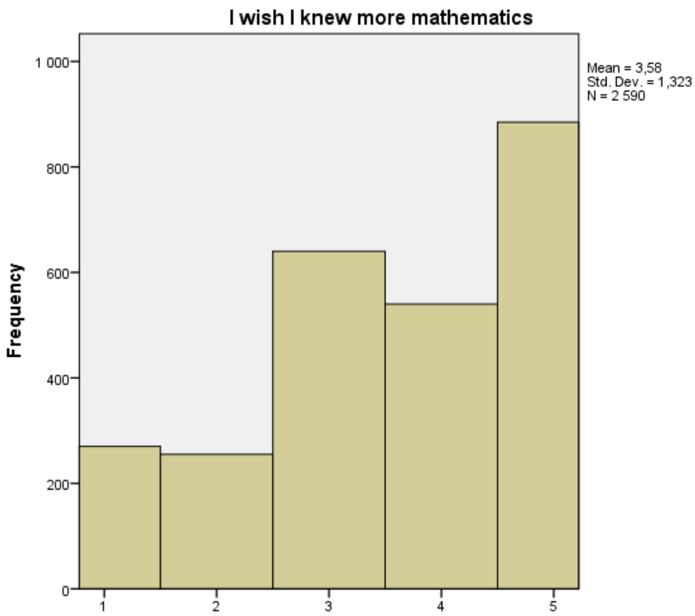


Figure 3.28: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

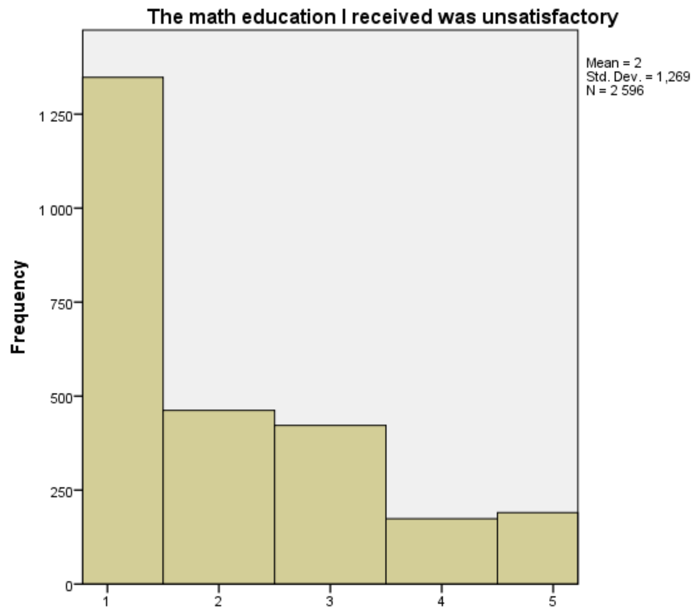


Figure 3.29: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

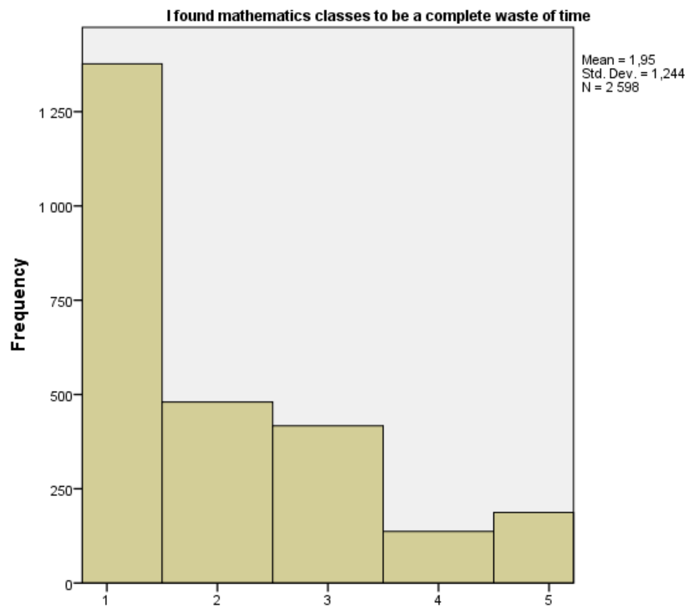


Figure 3.30: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

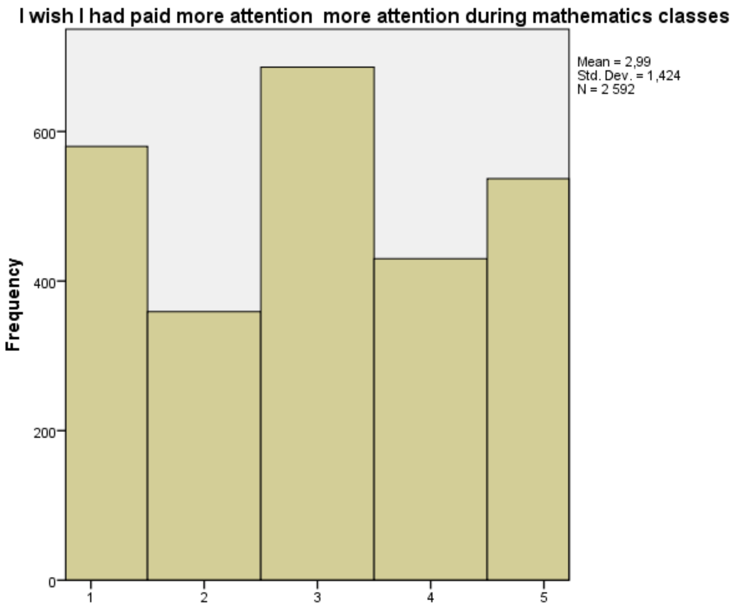


Figure 3.31: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

3.3.4 11-18 year old Serbian Students' Interpretation of Tools and Methods implemented in their Mathematics Education. The Cultural Embeddedness of Mathematics and its' Representation in Education

TAS 2013 has shown that the presentation methods of mathematics education content in school does not provide an account of the cultural embeddedness of mathematical knowledge and does not connect to the students' lives. Our results show that most Serbian mathematics teachers do not employ methodologies, tools or equipment that provide an experience-centered teaching of mathematics. If such an approach were effectively implemented, it would support students' creative and imaginative abilities in comprehending complex and difficult mathematical problems thus making mathematics classes more engaging.

Although at least a third of the students rarely used computers in mathematics classes, more than half have never used a computer in their mathematics class (Figure 3.32). This demonstrates that not only can students not rely on the support of computer applications in mathematics classes, but that teachers rarely use computers for the illustration of teaching content (e.g. in the form of PowerPoint presentations) (Figure 3.33). The situation is not significantly better in the case of using hands-on tools, physical models and other visualization apparatus. According to students' experiences, almost half of them have never had an opportunity to work with physical illustration materials in their mathematics classes (Figure 3.34). Computer games, as popular components of youth culture are almost entirely absent from the educational sphere (Figure 3.35). The Internet, which is one of the most significant sources of information for the students in their everyday lives, is also not incorporated into the mathematics education process (Figure 3.36). The situation is no better when it comes to exploring the cultural embeddedness of mathematics.

The practice of mathematics education in schools almost entirely excludes accounting for artistic connections to mathematics (Figure 3.37) and similarly does not refer to rhythm, dance, music or movies (Figure 3.38, 3.39). Visits to science centers and art or historical museums in order to discover and study mathematical connections is also a rare occurrence (Figure 3.40).

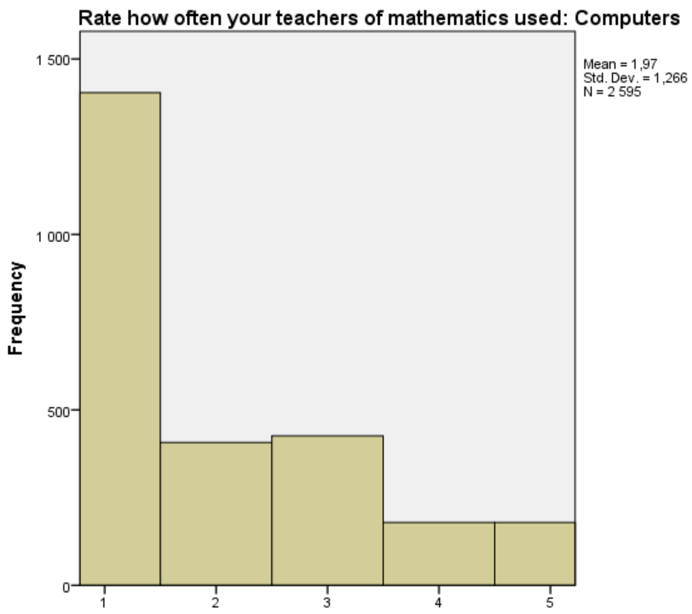


Figure 3.32: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

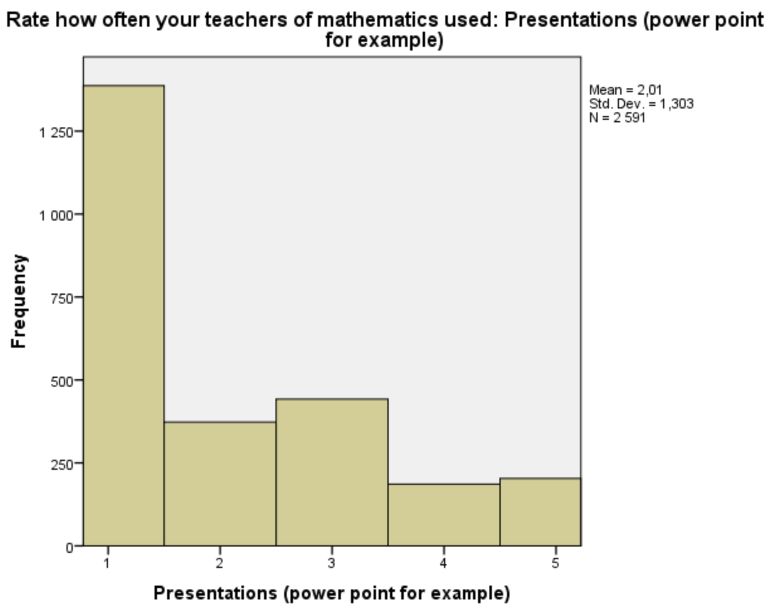


Figure 3.33: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

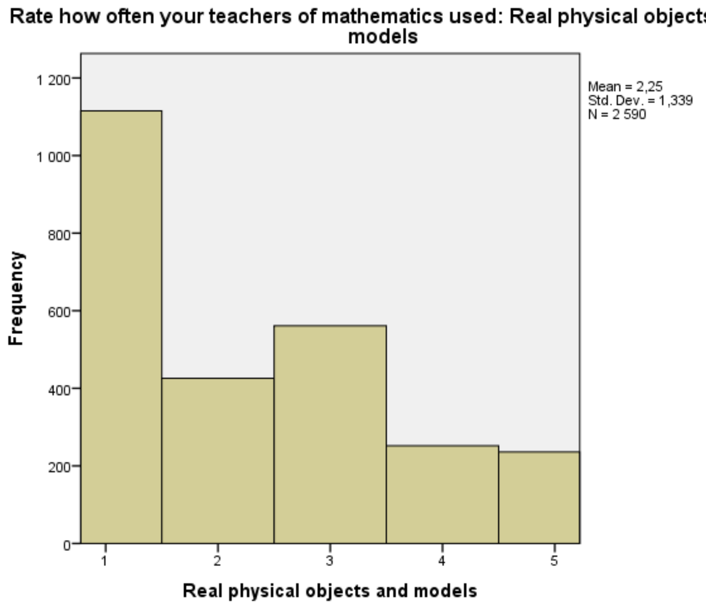


Figure 3.34: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

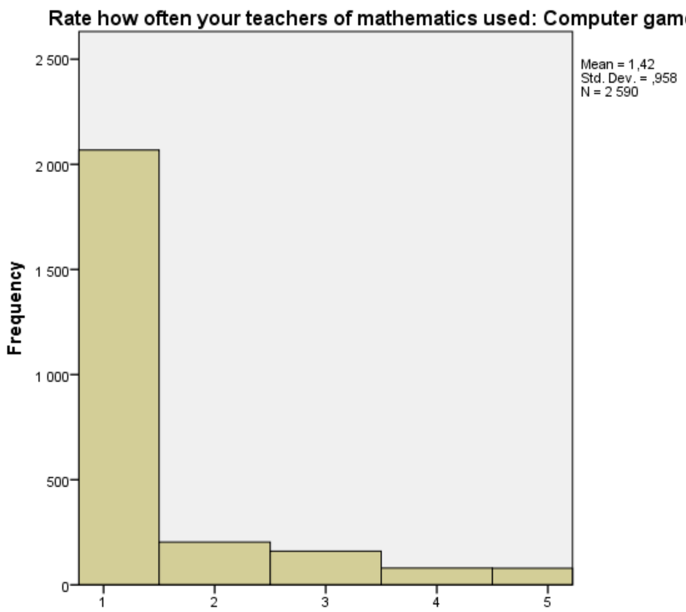


Figure 3.35: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

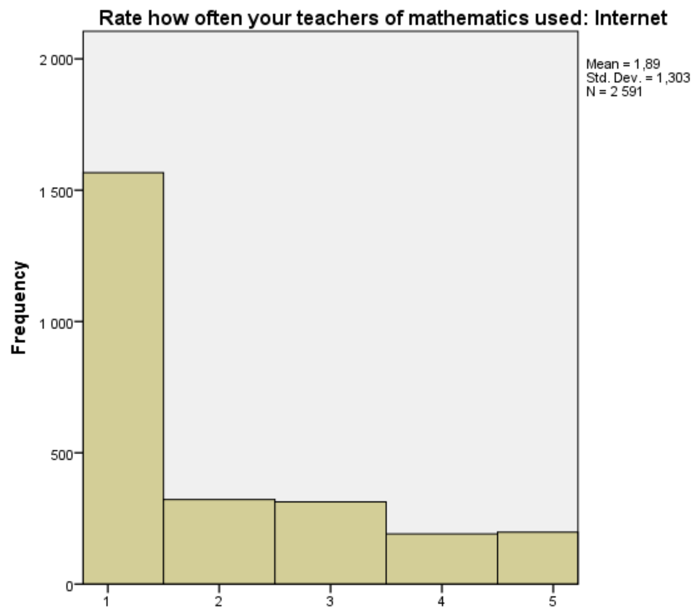


Figure 3.36: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

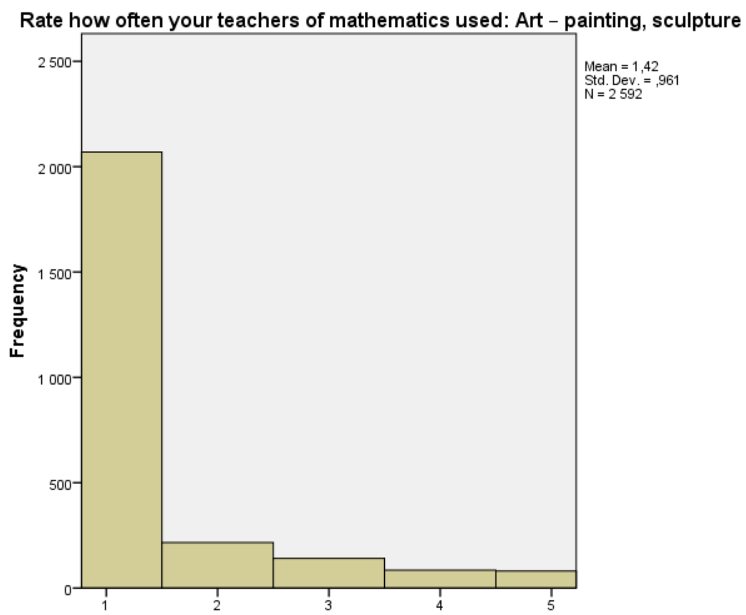


Figure 3.37: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

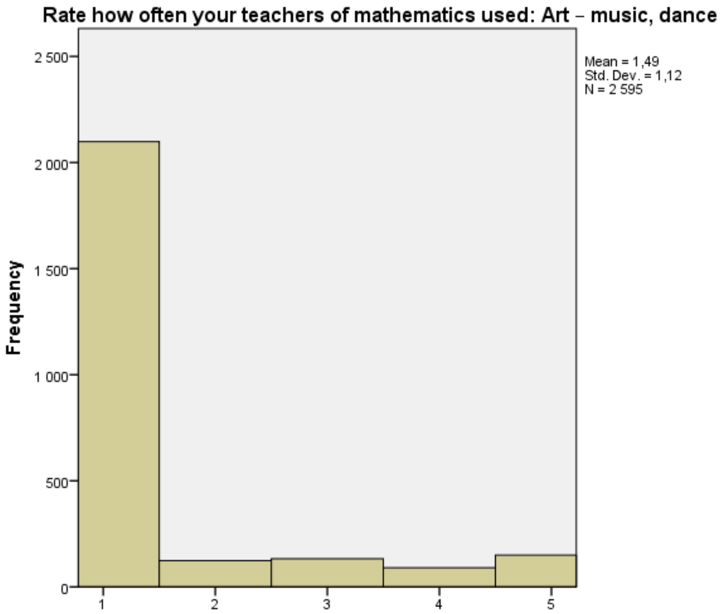


Figure 3.38: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

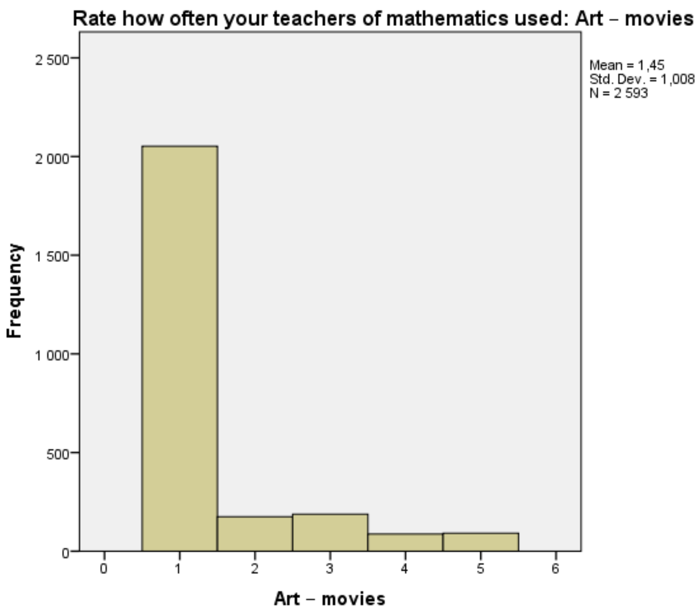


Figure 3.39: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

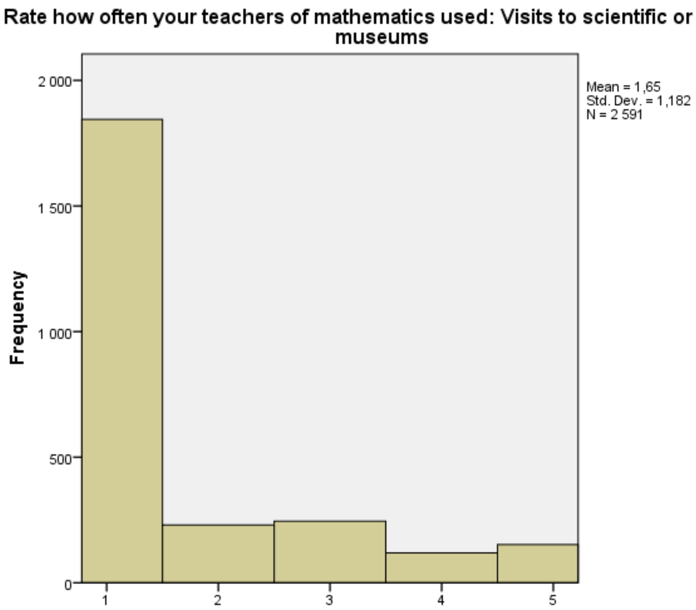


Figure 3.40: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

By contrast, the teachers seem to be more successful in including different kinds of narratives or episodes from the history of science to illustrate math problems: approximately half of the students experienced this regularly or at least sometimes (Figure 3.41).

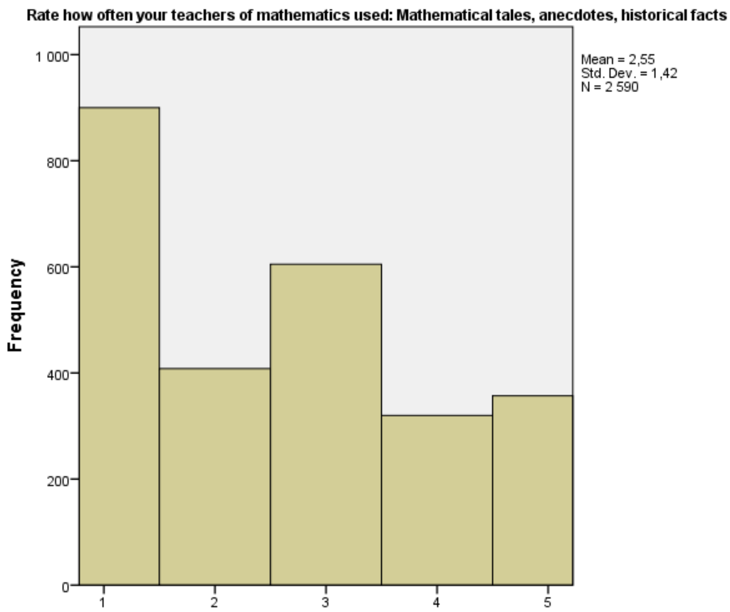


Figure 3.41: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

Taking everything into consideration, we have to see as a positive factor the fact that more than half of students do, at least sometimes engage in group work and carry out playful activities in math classes (Figure 3.42); however, approximately only a fifth of the students engaged in individual playful activities regularly or at least occasionally in mathematics classes (Figure 3.43). Most students never took part in role-plays connected to mathematics content (Figure 3.44) and never participated in education-related outdoor activities during class time (Figure 3.45).

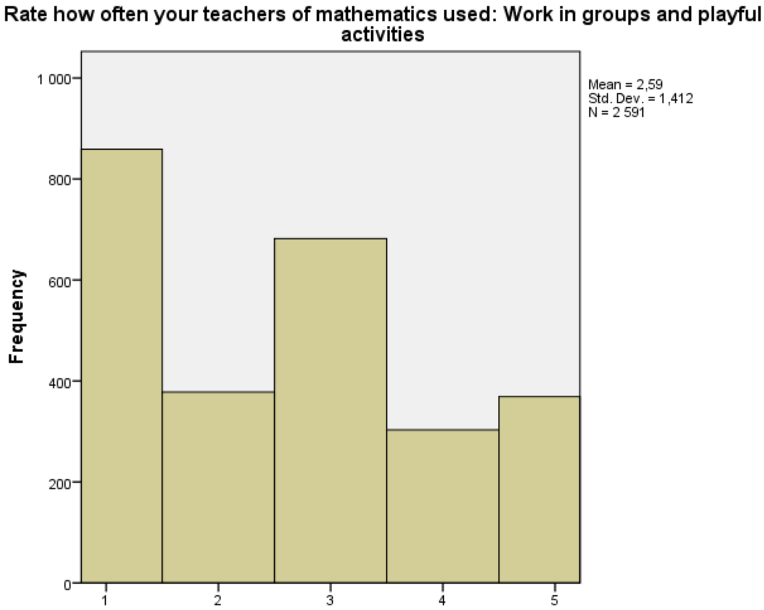


Figure 3.42: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

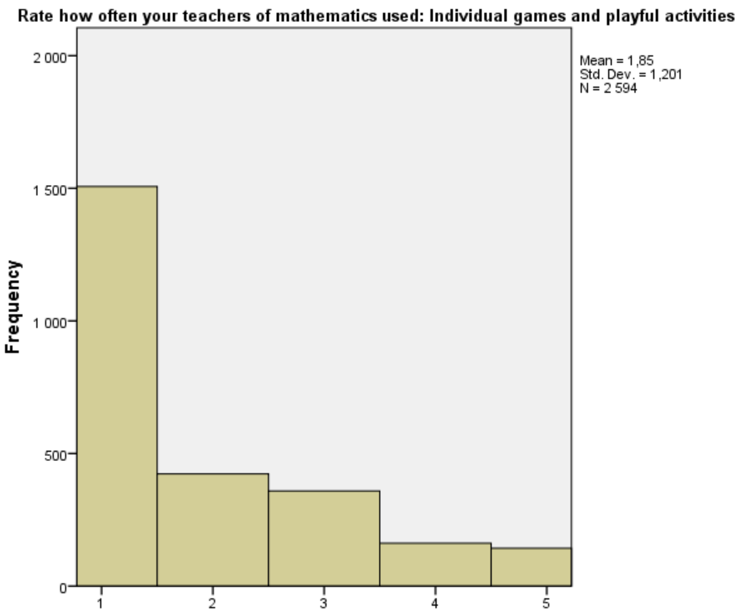


Figure 3.43: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

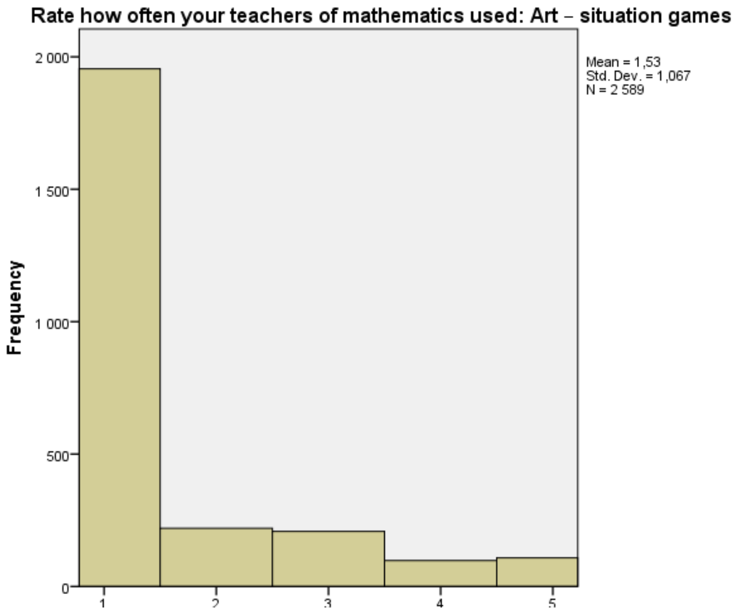


Figure 3.44: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

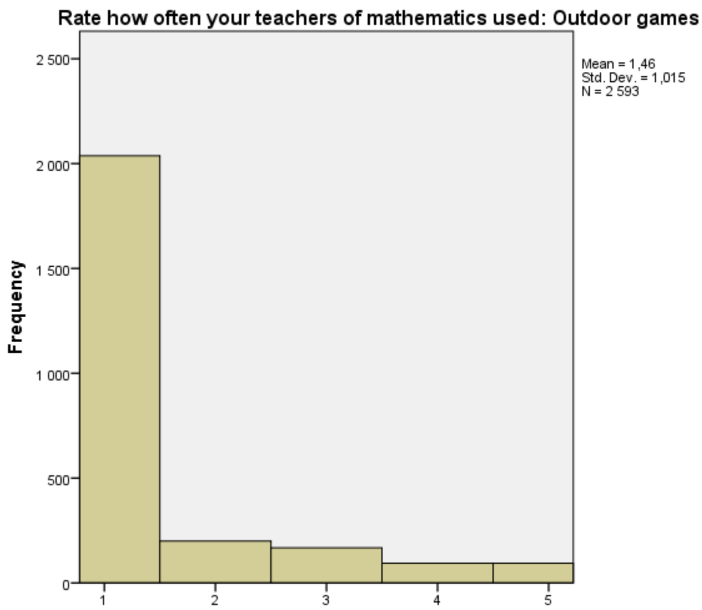


Figure 3.45: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

3.3.5 Cross Tabulations for 11-18 year old Serbian Students

3.3.5.1 Methodological and Instrumental Diversity in the Practice of Serbian Mathematics Teachers

Our survey has shown that a rich variety of different methods and instruments exists in Serbian mathematics education, but these are not prevalent, most being implemented by only a small number of teachers to a rather limited number of students. In this regard, equal access to instruments of learning and special knowledge and perspective, which can be acquired by the implementation of specific tools and methods, is not widespread in Serbian mathematics education. With respect to this issue we wanted to explore the relationship teachers might have with the implementation of different education methods and instruments.

To measure this, we looked at all the claims in question group nr. 13 (see: Appendix), which refers to the usage of specific methods and tools and using cross tabulation we found that there is a correlation between the variety of utilised teaching methods and the students of certain teachers. What this means is that despite a rich variety of art-related, experience-centered, playful methods and learning tools existing in Serbian mathematics education, these are not widespread, most implemented only by a small number of teachers for a rather limited number of students. Teachers, who use certain experiential approaches or tools frequently, are also more likely to implement other experimental content in their classes. It follows then, that encouraging the implementation of experimental content opens the door to further methods. The implementation of a certain experimental tool or method seems to work as a "magnet" in relation to other experimental tools and methods. The reasons of exactly why and how, might be a topic of further research. It is, however, one of the keys to methodological and instrumental diversity in mathematics teaching.

3.3.5.2 Methodological and Instrumental Diversity and Student Attitudes

We were also curious to see if there is any correlation between teachers' methodological and instrumental diversity and their students' positive attitudes towards the role of mathematics in life and mathematical knowledge as it is taught in school. To examine this problem, we compared the answers students gave in the question group nr. 13 and the students' claims in question group nr. 3 and 4 (see: Appendix).

We found that students of those teachers advocating methodological and instrumental diversity in their teaching process are more likely to *agree* with claims like

- mathematics is essential for all humans
- mathematics improves intelligence
- mathematics is the most important class in school
- knowing mathematics opens the door to a future career
- most teachers of mathematics are very good

Consequently, students of those teachers, who advocate methodological and instrumental diversity in their teaching process, are more likely to *disagree* with the claim

- Most people were bored at mathematics classes. (Students who were exposed to diverse teaching methods are more likely to say that classmates were not bored.)

Meanwhile students of those teachers who work with a more restricted set of methods and instruments in their teaching are more likely to agree with claims such as

- mathematics is difficult and hard
- mathematics is not important for everyday life
- I could learn more mathematics if it was presented in a better way
- most people were bored at mathematics classes

The same students are more likely to *disagree* with the claim

- mathematics was always easy for me

Cross tabulation analysis has demonstrated that grades depend on all the effort measuring variables, that is, it provides us with evidence that when more effort is expended better grades are achieved. There is a correlation between the students' claims that they find mathematics classes boring (question group nr. 11, claim 'h', see: Appendix) with the claims concerning assistance with learning (question group nr. 11, claim 'b' and higher values in the question group nr. 12, see: Appendix). This demonstrates that children who think mathematics classes are boring need more help with learning.

3.3.6 Gender Differences In 11-18-Year-Old Serbian Students' Responses

Analysis of gender differences shows that girls are more successful in school than boys. Girls have a better average in general (Figure 3.46) and better grades in mathematics as well (Figure 3.47). Therefore, more girls assume their parents are happy with their mathematics performance than boys. (Figure 3.48).

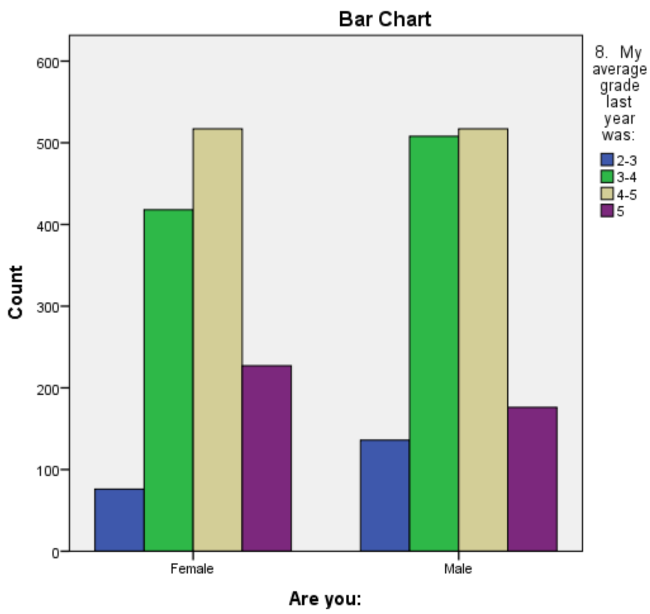


Figure 3.46

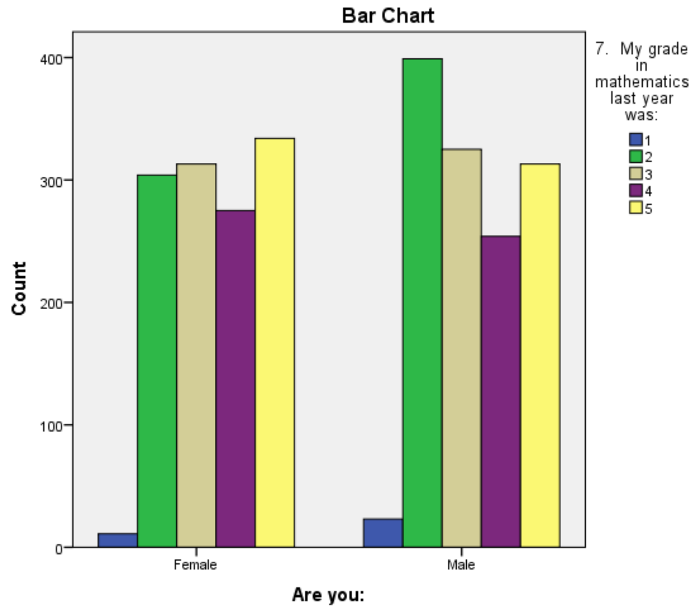


Figure 3.47

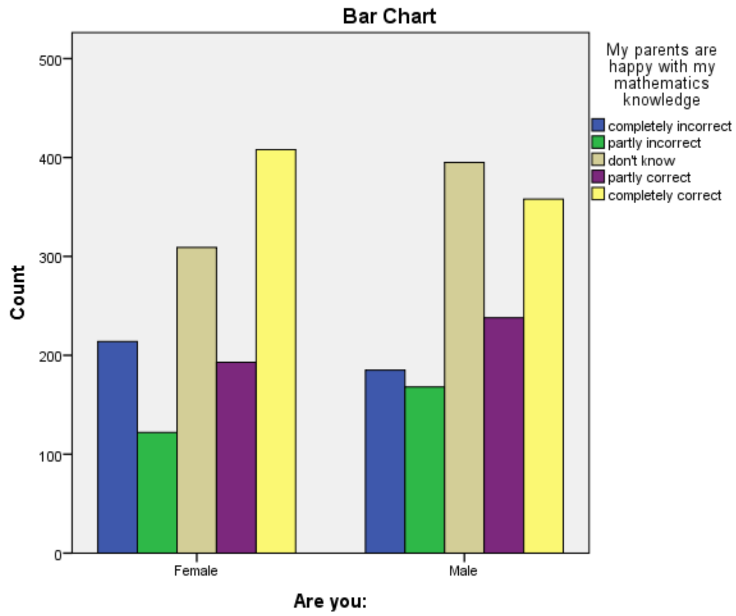


Figure 3.48

Meanwhile, boys see knowledge of math as more important for everyday life than girls (Figure 3.49). But regarding the social importance of mathematics only the acceptance of the claim "Mathematics is the most important course in school" (question group nr. 3, claim "e", see: Appendix) reveals a difference in attitude between the two genders: boys are more likely to accept this claim than girls (Figure 3.50).

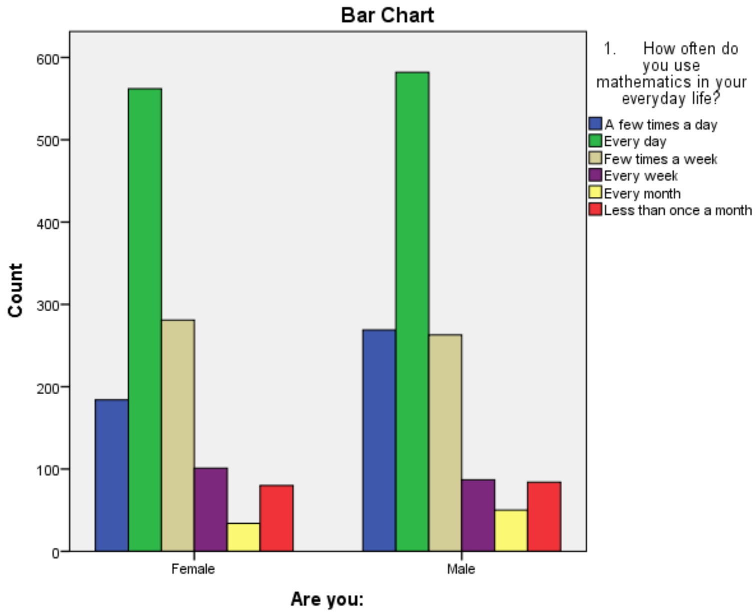


Figure 3.49

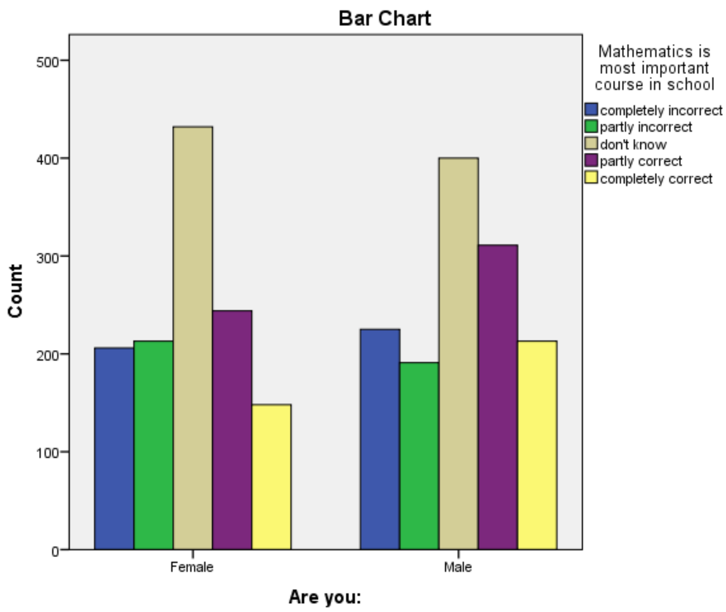


Figure 3.50

At the same time it is important to emphasize that according to their own accounts, girls spend more time studying mathematics at home than boys (Figure 3.51), and they can access more help in learning as well, if required (Figure 3.52). Also, girls take more extra mathematics classes (Figure 3.53).

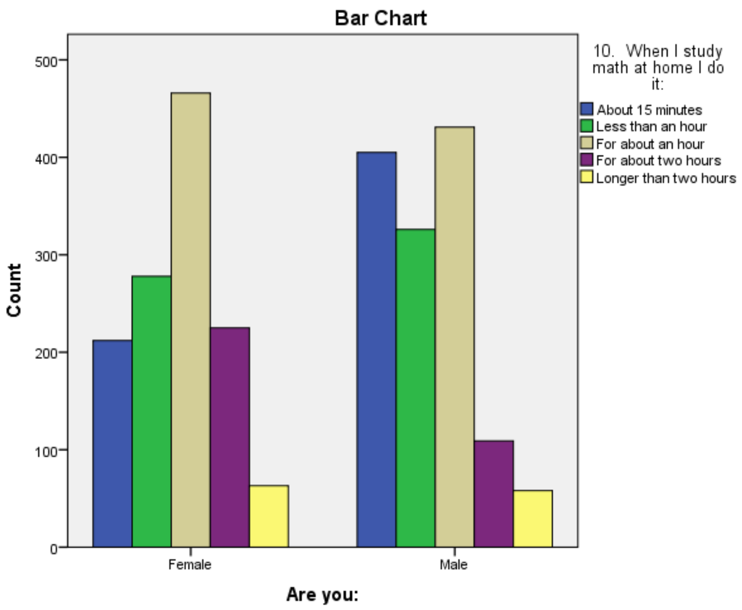


Figure 3.51

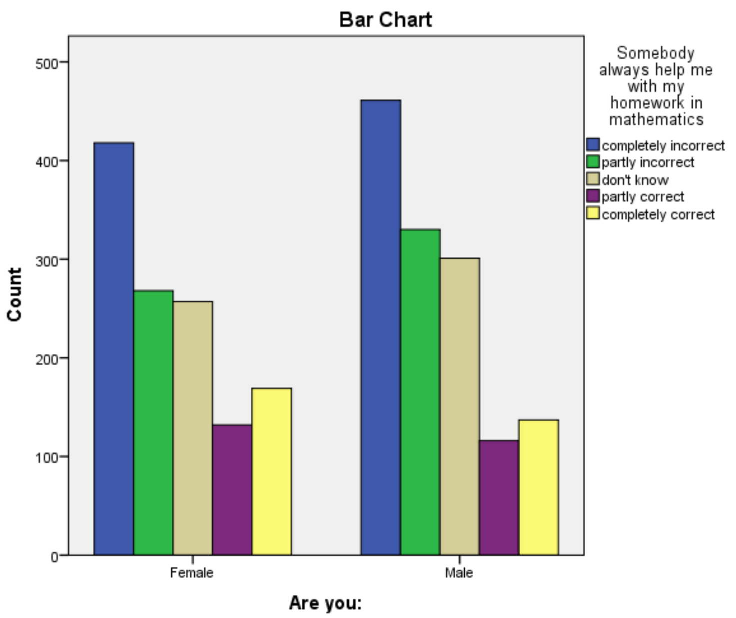


Figure 3.52

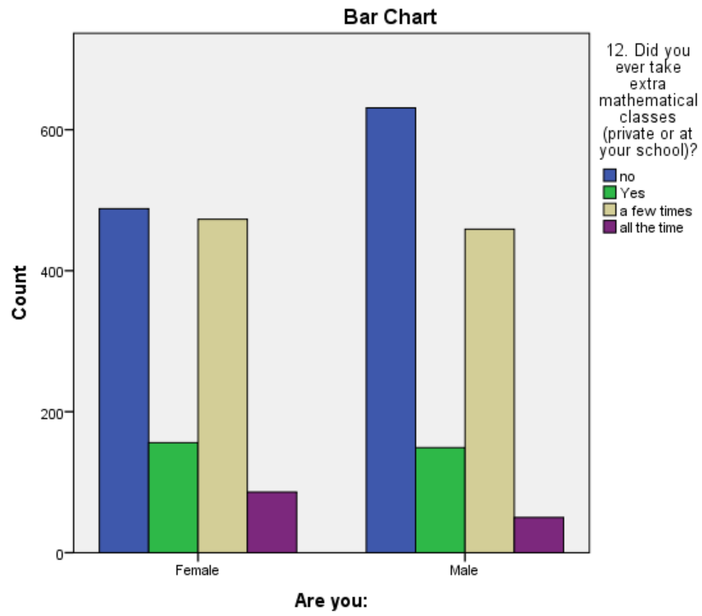


Figure 3.53

A greater percentage of boys think that mathematics is easy (Figure 3.54), yet they are more likely to state that they wished they paid more attention in mathematics classes (Figure 3.55).

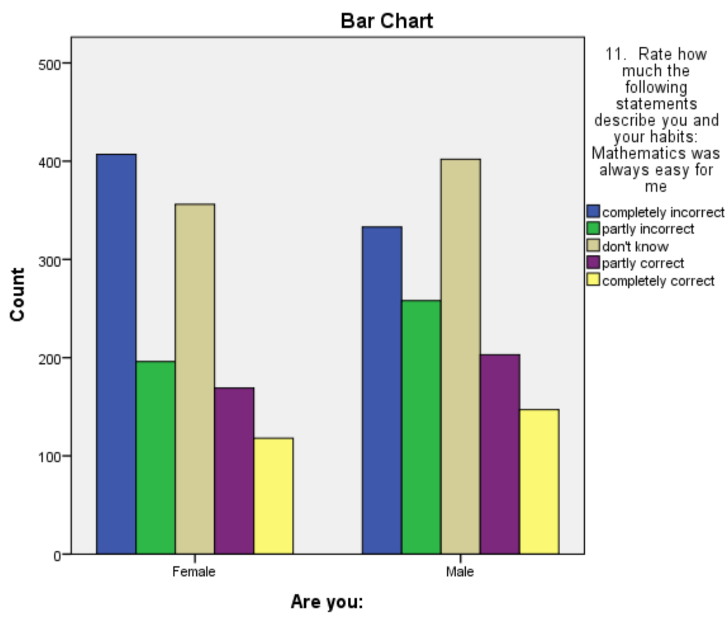


Figure 3.54

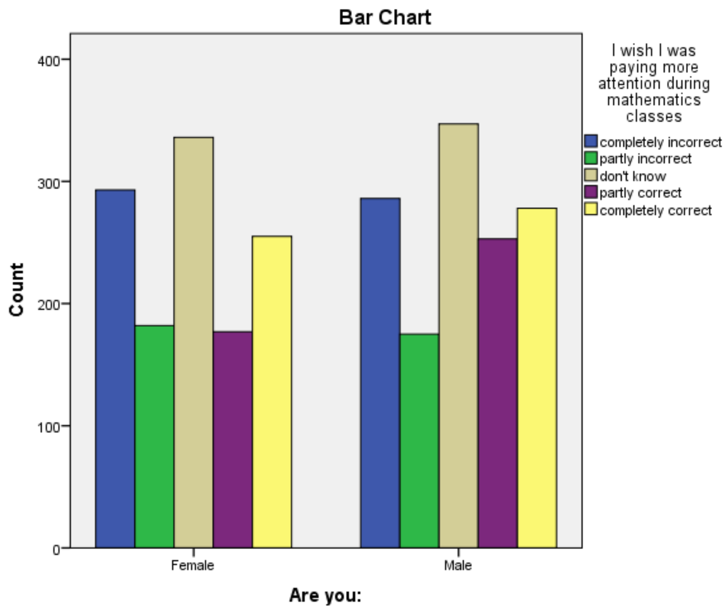


Figure 3.55

In connection with teaching and learning methods, girls are more likely to say that "mathematics could be taught in a more entertaining way" (Figure 3.56) and that they would learn more mathematics if the teaching would be more interesting (Figure 3.57). This is supported by the fact that more girls than boys agree with the claim that "our classes in mathematics were boring" (Figure 3.58).

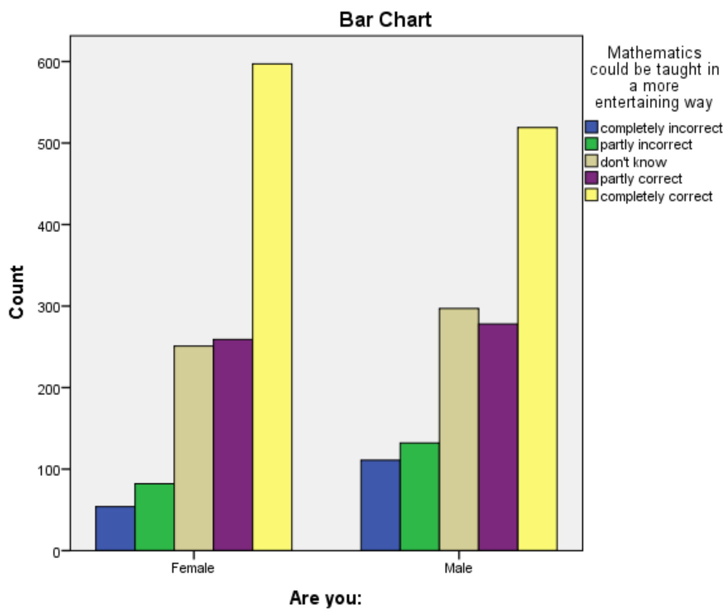


Figure 3.56

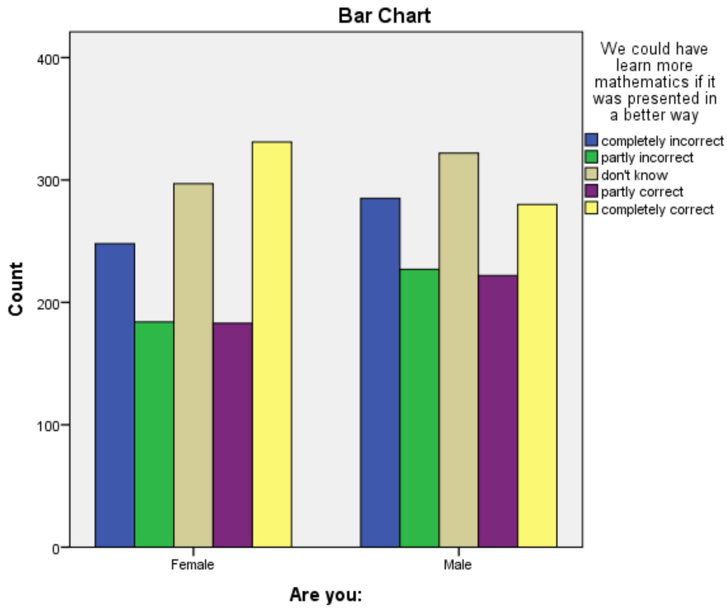


Figure 3.57

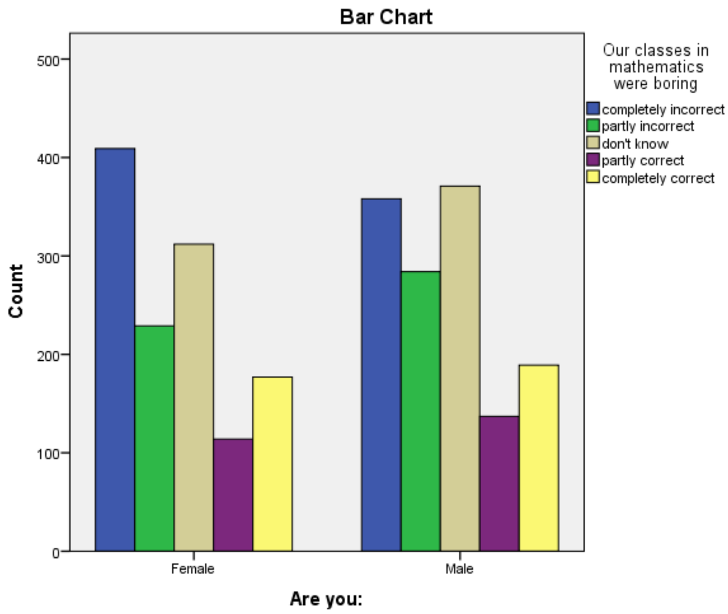


Figure 3.58

Regarding the students' recognition of the methodological and instrumental diversity of teaching methods experienced in mathematics classes, there are interesting differences between girls and boys. One would think any variation in gender responses to such a question would be minimal to zero (unless the sample included single-sex schools). This is, however, not the case still in most of the categories listed under question group 13 (see: Appendix), there are marked differences. Boys have experienced more varied teaching. Maybe teachers' efforts to make mathematics classes more interesting are catching the boys' attention more? Or perhaps teachers are making math classes more interesting from a male-perspective? The reasons for this variation could be a topic for further research.

3.4 TEMPUS Attitude Survey 2013 for Serbian Students above 18 Years of Age

Mathematics learning is of crucial importance in many fields of higher education. We conducted our survey among 178 university and college students, in whose education mathematics plays a central role. More than half of the students surveyed were from Belgrade Metropolitan University (57,9%), almost a third from ICT College of Vocational Studies (30,3%) and a much smaller proportion from both the University of Novi Sad (6,2%) and the Mathematical Institute of the Serbian Academy of Sciences (5,6%) (Figure 3.59).

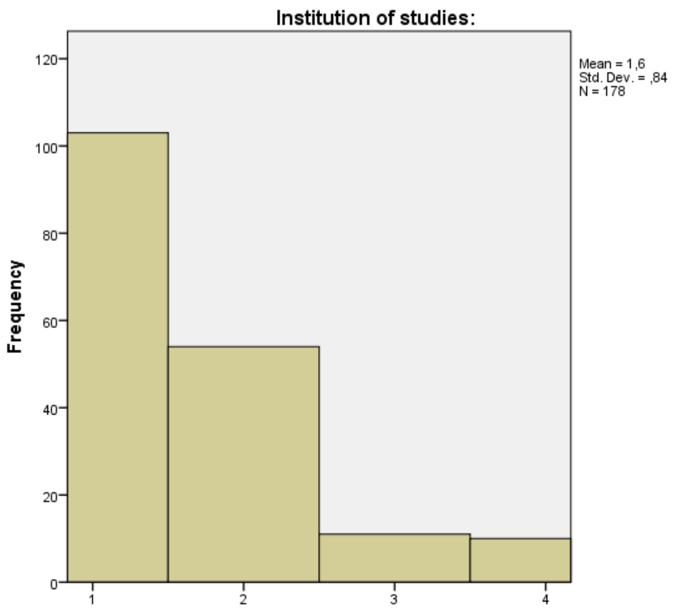


Figure 3.59: 1- Belgrade Metropolitan University, 2- ICT College of Vocational Studies, 3- University of Novi Sad, 4- Mathematical Institute of Serbian Academy of Sciences

3.4.1 Demography of Tempus Attitude Survey 2013 for Serbian Students above 18 Years of Age

The respondents came from various fields, meaning that they learn various branches of mathematics. The following areas were represented in the survey:

- 1- Information technology (23
- 2- IT software engineering
- 3- Graphic design of print
- 4- Media
- 5- Operations management (8,4
- 6- Information security

- 7- Information technology
- 8- Information systems
- 9- New media design
- 10- Marketing management
- 11- Management information systems
- 12- Internet technologies (12,9
- 13- Telecommunications
- 14- Mathematics (2,8
- 15- Applied mathematics
- 16- Financial mathematics
- 17- Computer science
- 18- Mathematics in engineering
- 19- Medical Informatics
- 20- Pure and applied mathematics
- 21- Digital arts
- 22- Interactive media design
- 23- Graphic design
- 24- Banking technology
- 25- Network technology

The respondents' ages ranged from 19 to 48 years (Figure 3.60). The largest proportion came from the 19-24 age group, more than 50%. The gender distribution of the survey participants was balanced, as 42,7% females and 57,3% males participated in the research.

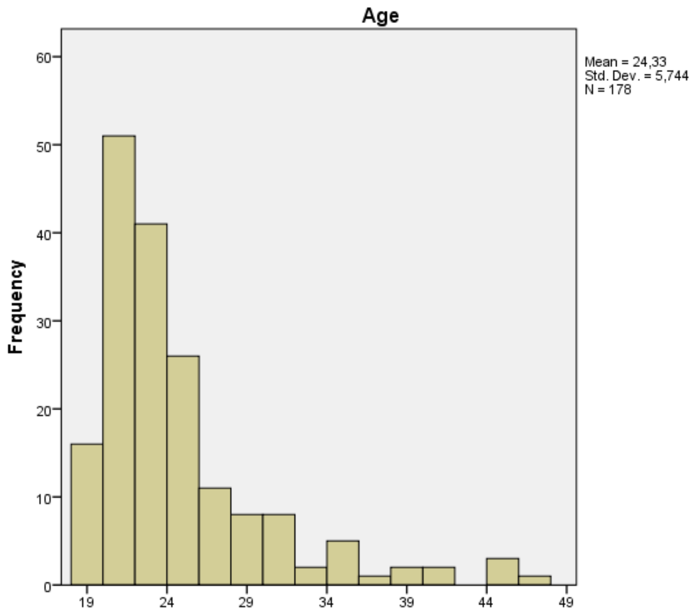


Figure 3.60

Regarding the respondents' life circumstances: 93,8%, a vast majority of respondents, live in urban areas, and 6,2% of them live in villages.

In this age group family background plays only a minor role. However, most of the respondents' mothers' highest education attainment was secondary school (55.6%), 38.2% of the respondents' mothers' highest education attainment was university and only 5.6% had elementary school as their highest education attainment. In the case of mothers who had university degrees, most of them graduated in law or economics (16.9%) while natural sciences or mathematics had the least graduates. In the case of the fathers, the situation was similar to the mothers regarding educational background. Most of them had a secondary school education or university degree in a similar percentage to the mothers, but in the case of fathers the number with a natural sciences or mathematics degree was higher.

3.4.2 Views on the Role Mathematics Plays in Life and the Importance of Mathematics as a School Subject for Serbian Students above 18 Years Old

As most of the surveyed students' field of studies is in some way connected to mathematics, it is not surprising that they attach great importance to mathematical knowledge in their everyday lives (Figure 3.61). They consider it universally relevant (Figure 3.62) and, just like students less than 18 years of age, they assume a close tie between mathematics and intelligence: a large majority of them agree that learning mathematics improves intelligence (Figure 3.63). They see mathematics not only as a subject in school, but as a field of knowledge which they can utilize and rely on in their everyday lives (Figure 3.64).

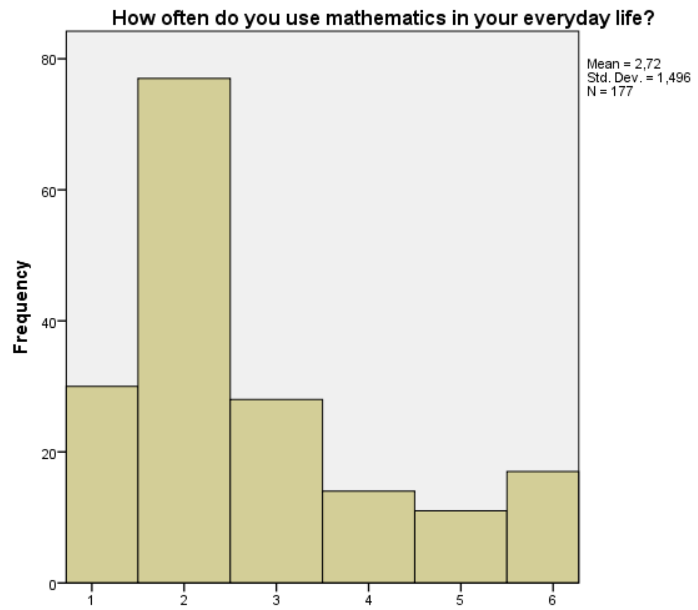


Figure 3.61: 1- A few times a day, 2- Every day, 3 Few times a week, 4- Every week, 5- Every month, 6- Less than once a month

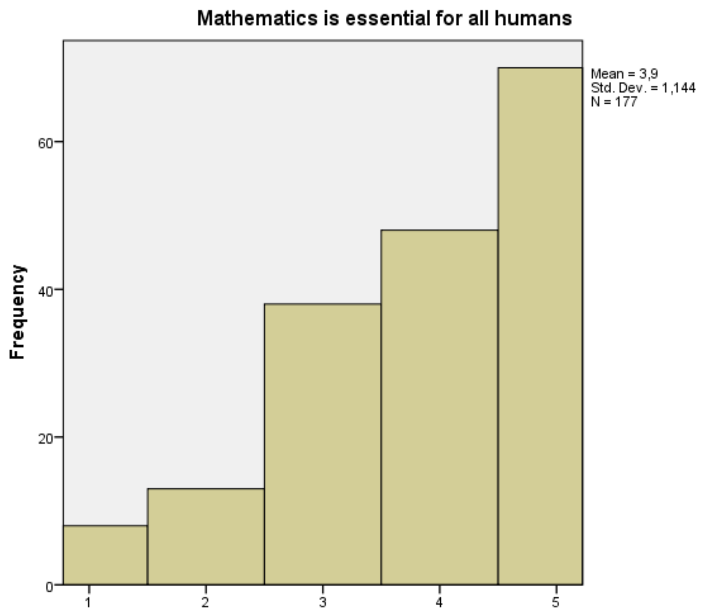


Figure 3.62: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

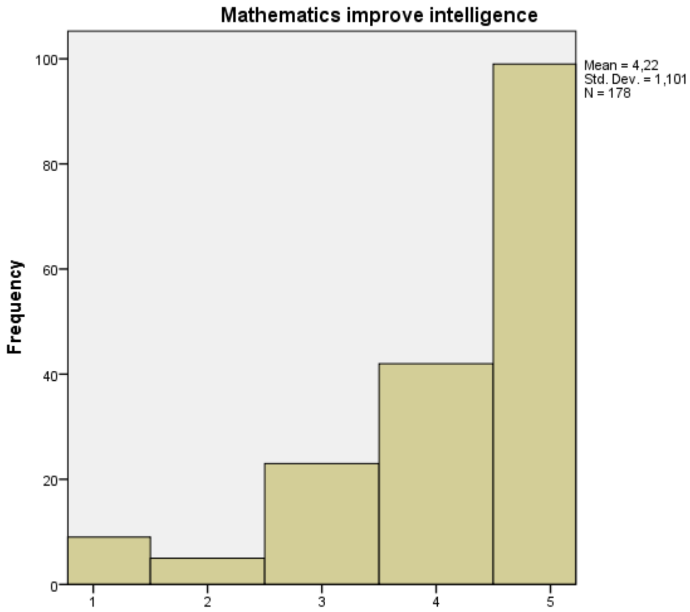


Figure 3.63: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

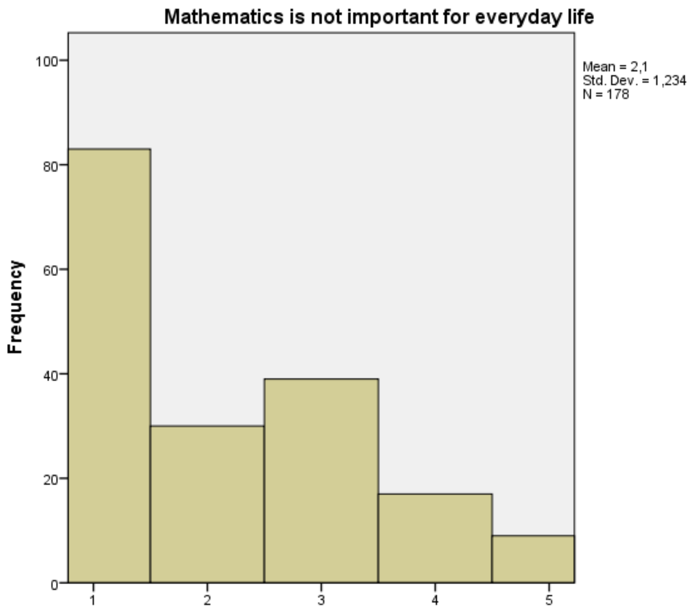


Figure 3.64: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

However, it is interesting that they are far less convinced that the acquisition of mathematical knowledge to a high level is something which leads to better career opportunities. 32.8% of the students gave a somewhat evasive answer to the question concerning mathematics and careers (Figure 3.65).

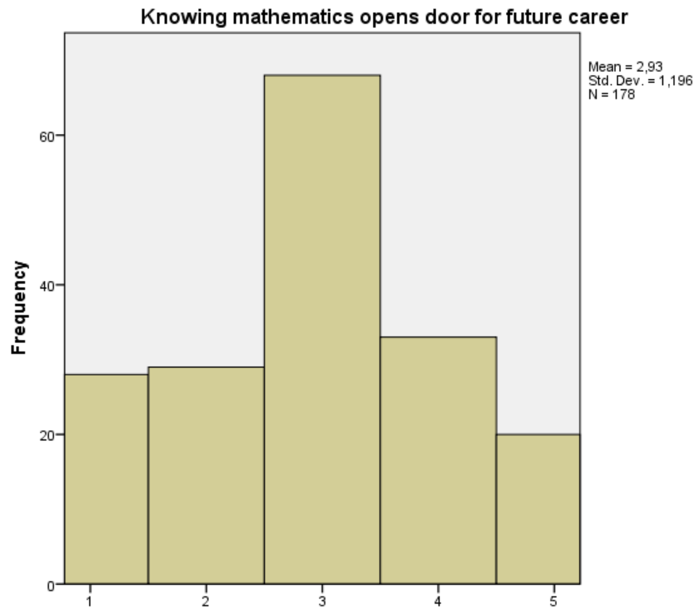


Figure 3.65: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

The importance of family background and parental expectations is lower for the students in this age group, but all the opinions above are supported by the students' views of their parents' attitude to mathematical knowledge (Figure 3.66, 3.67).

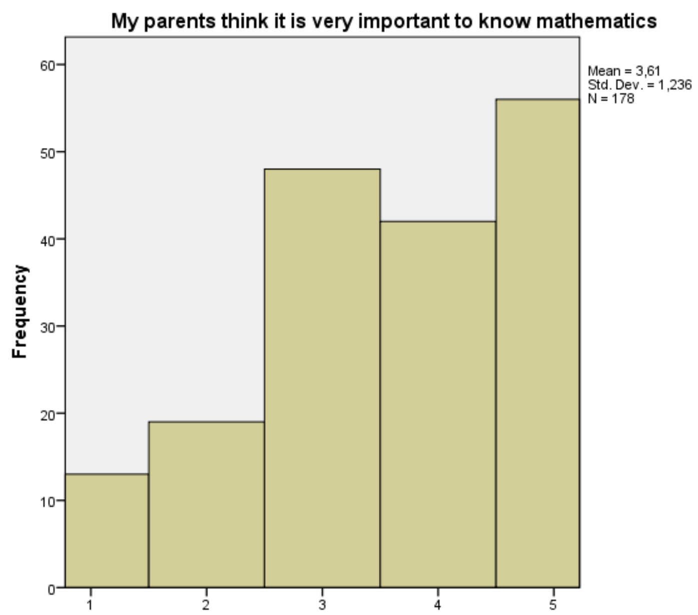


Figure 3.66: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

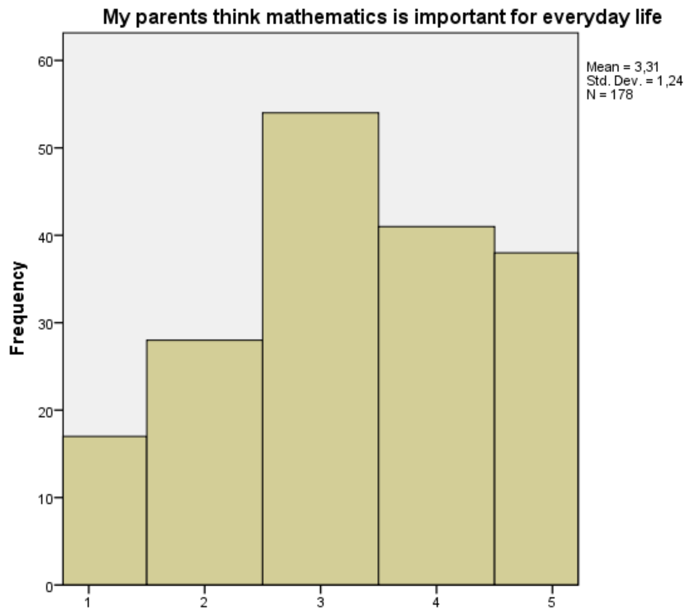


Figure 3.67: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

Most of the students in this age group are bored in mathematics classes (Figure 3.68), just like the students under the age of 18. However, the students who are studying mathematics at a high level and have more mathematical knowledge and experience, are more convinced that mathematics can be taught in a more interesting way (Figure 3.69). Compared to the under 18 age group this age group are much more uncertain as to whether there is enough mathematics taught in school or not (Figure 3.70), but they more openly criticize teachers' preparedness (Figure 3.71) and uniformly claim that they would have learned more mathematics if their teacher would have used more interesting teaching methods (Figure 3.72).

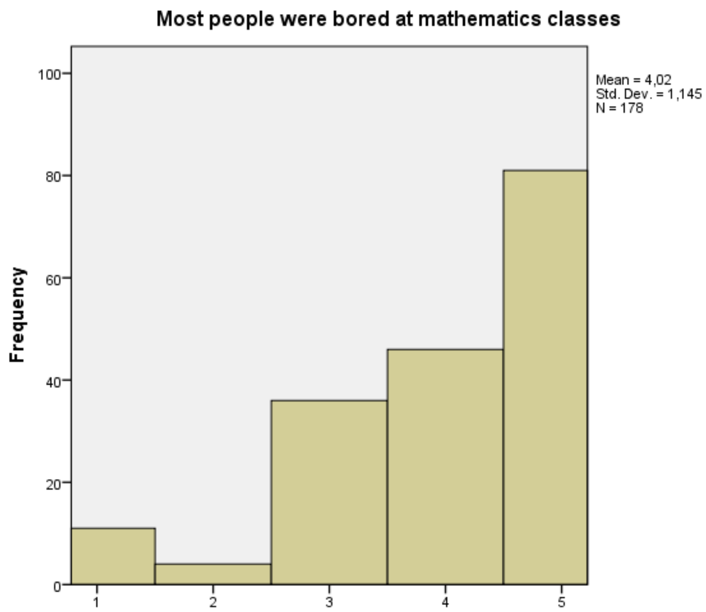


Figure 3.68: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

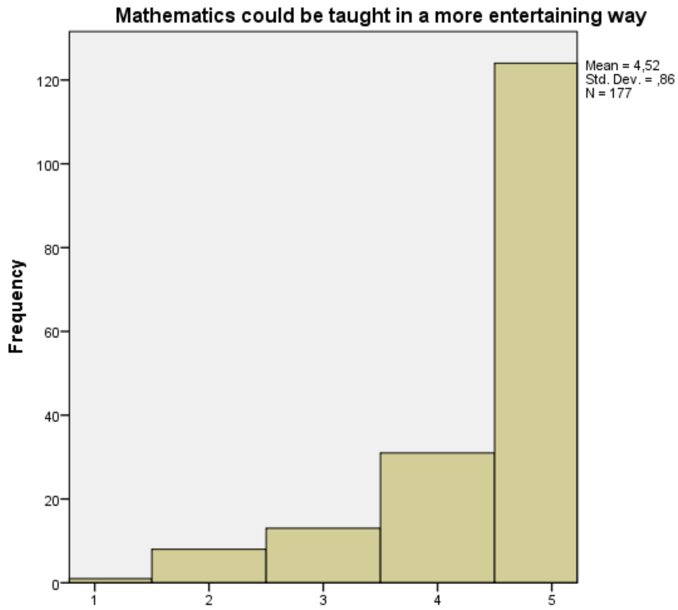


Figure 3.69: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

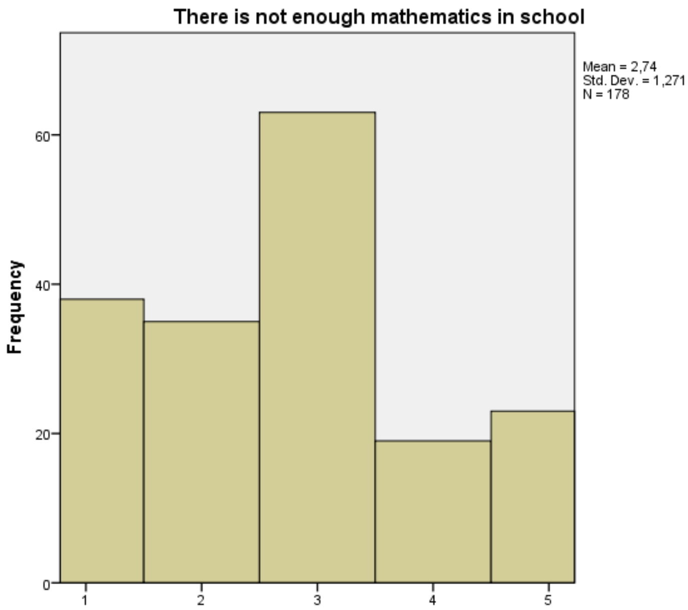


Figure 3.70: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

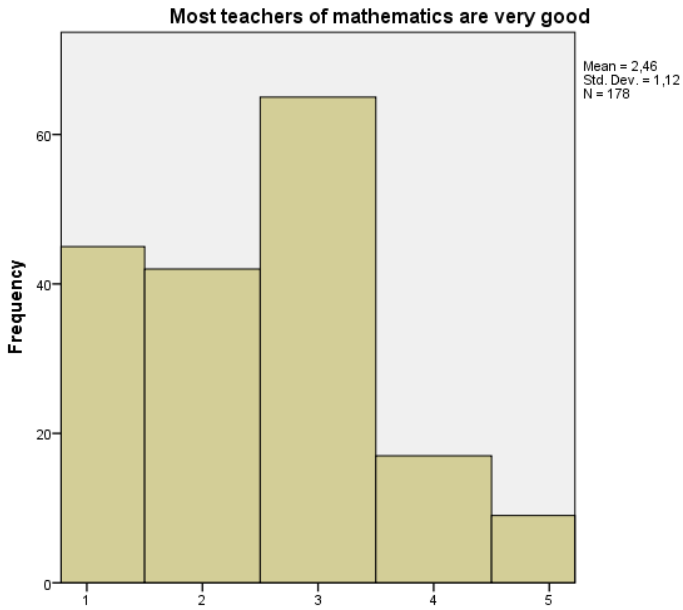


Figure 3.71: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

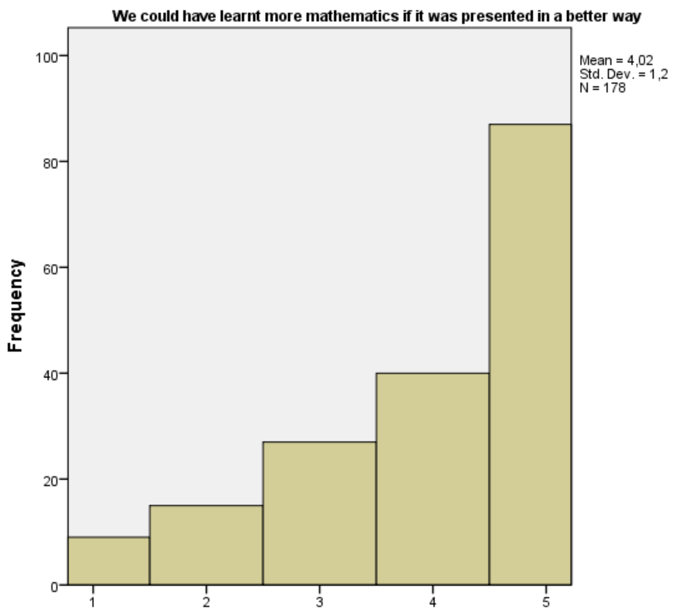


Figure 3.72: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

3.4.3 Efforts and Challenges in Mathematics Learning for Serbian Students over 18 Years of Age

As mathematics is an important part of the surveyed students' curriculum, it is not surprising that they think they have learnt a lot of mathematics during their school years and that they were able to acquire all the knowledge they needed. They do not explicitly think that the mathematics instruction they received was insufficient

(Figure 3.73). They are mostly satisfied with the evaluation of their knowledge (Figure 3.74).

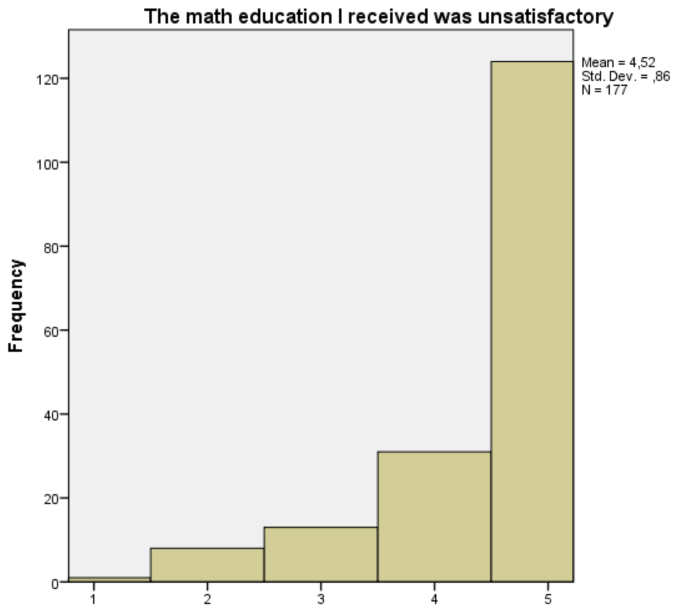


Figure 3.73: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

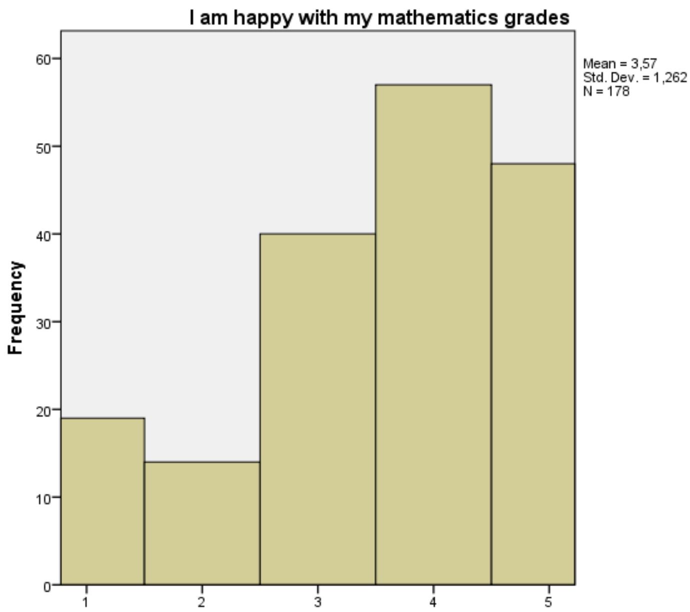


Figure 3.74: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

Naturally, they believe learning mathematics was easier than the 11-18 year old students do, and it also comes as no surprise that they are much more determined when it comes to increasing their mathematical knowledge: they would like to achieve much more in mathematics. They do not feel spending time learning mathematics is a waste of time (Figure 3.77), and they relied much less on help when having to learn mathematics at home (Figure 3.78). Paying attention in mathematics classes in school is not particularly challenging (Figure 3.79) and they find lessons much more interesting than their younger counterparts (Figure 3.80). Their answers to the question about taking extra classes are broadly similar to those of the under 18s (Figure 3.81).

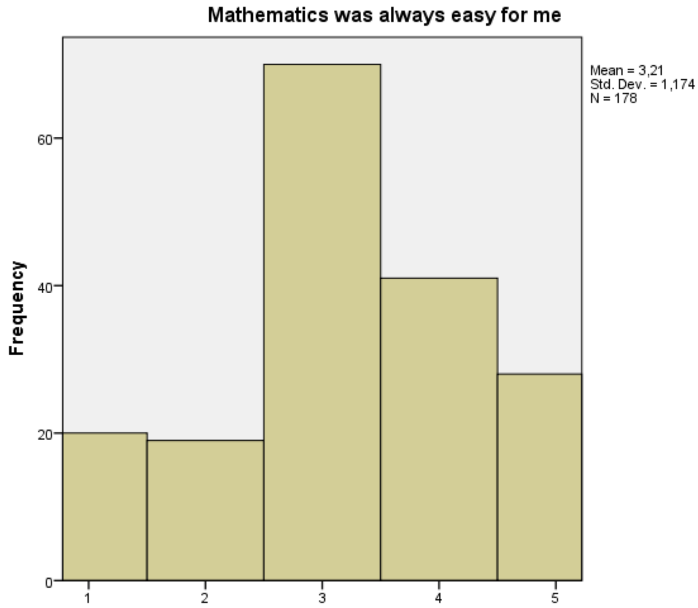


Figure 3.75: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

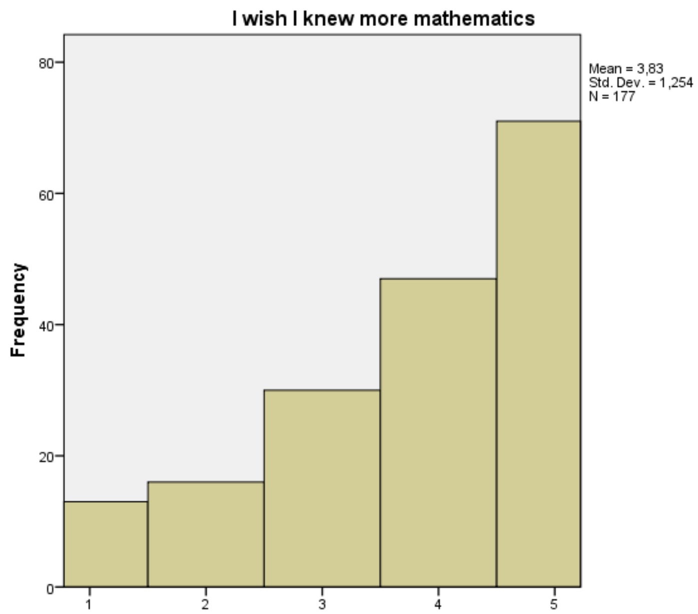


Figure 3.76: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

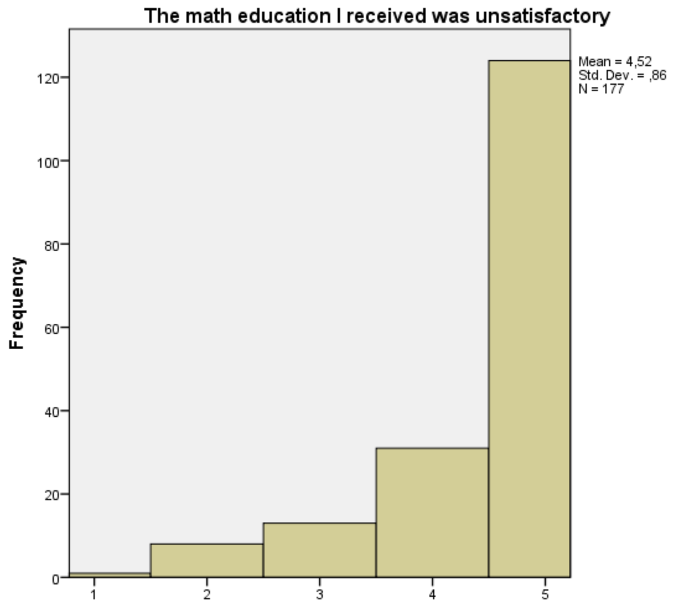


Figure 3.77: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

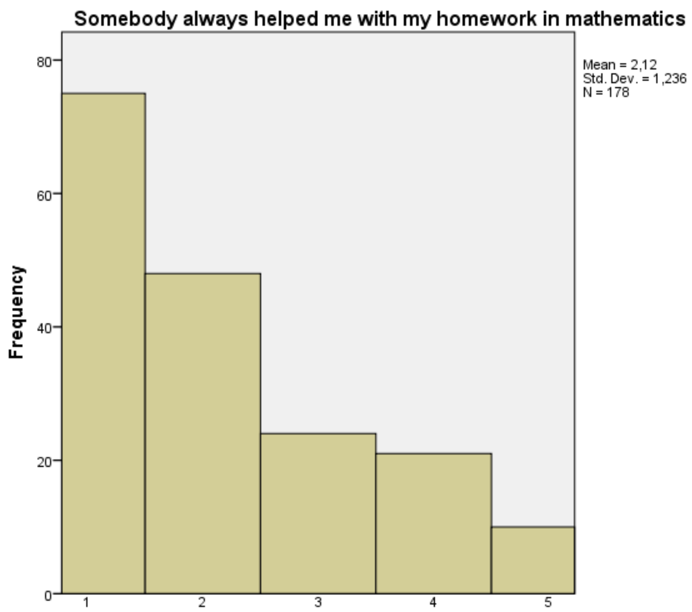


Figure 3.78: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

Figure 3.79: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

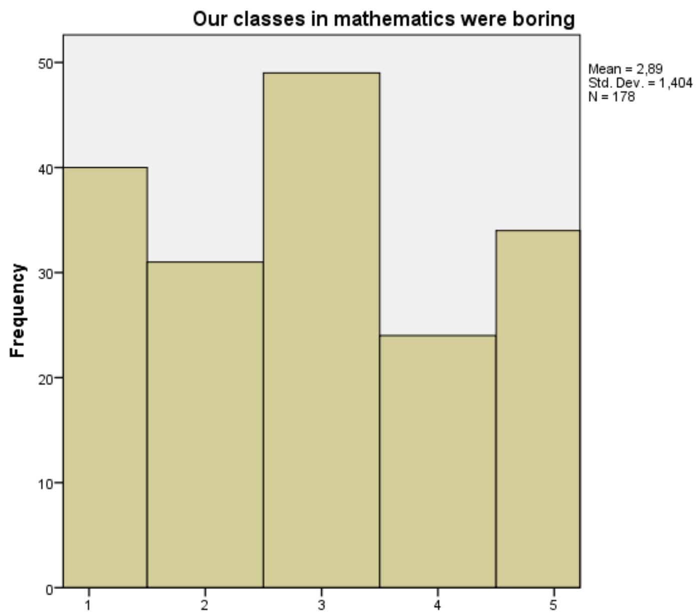


Figure 3.80: 1- Completely incorrect, 2- Incorrect, 3- Neutral, 4- Correct, 5- Completely correct

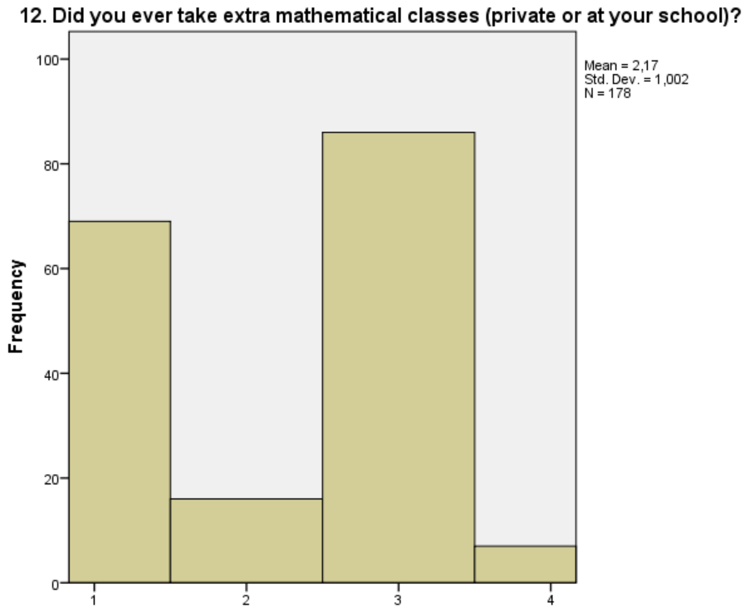


Figure 3.81: 1- NO, 2- YES, 3- A few times, 4- All the time

3.4.4 Interpretation of Tools and Methods Implemented in Mathematics Education. Mathematics' Cultural Embeddedness and its Representation in School Education for Serbian Students over 18 Years of Age

Interestingly, computers are rarely employed in the classroom even in those higher education study programs where mathematics is a central element of education (Figure 3.82). The Internet (Figure 3.83) and basic presentation tools like PowerPoint are also seldom used (Figure 3.84). Teachers using models during instruction is also very rare, but the situation is a little bit better than in the case of students under 18 (Figure 3.85). Computer games are almost entirely absent from mathematical education and utilised even less than in the case of students less than 18 (Figure 3.86). Traditional forms of playful education are almost entirely missing as well (Figure 3.87). Similarly to the students under 18, the situation is equally poor when it comes to presenting the cultural embeddedness of mathematics. Mathematics education practice in Serbia, apart from some delightful exceptions, almost entirely excludes all accounts of the connections between mathematics and art, rhythm, dance, music and movies (Figure 3.88-3.91). Trips to science centers and art or historical museums in order to discover and study mathematical connections, also happen very rarely (Figure 3.92).

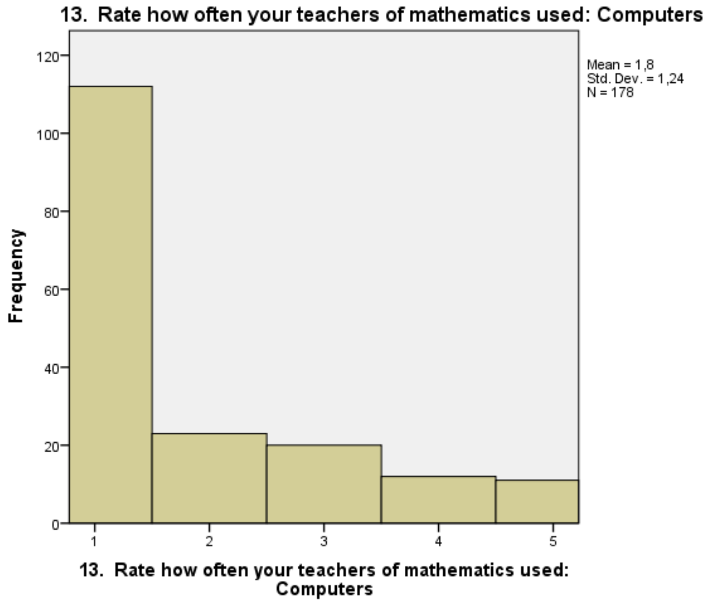


Figure 3.82: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

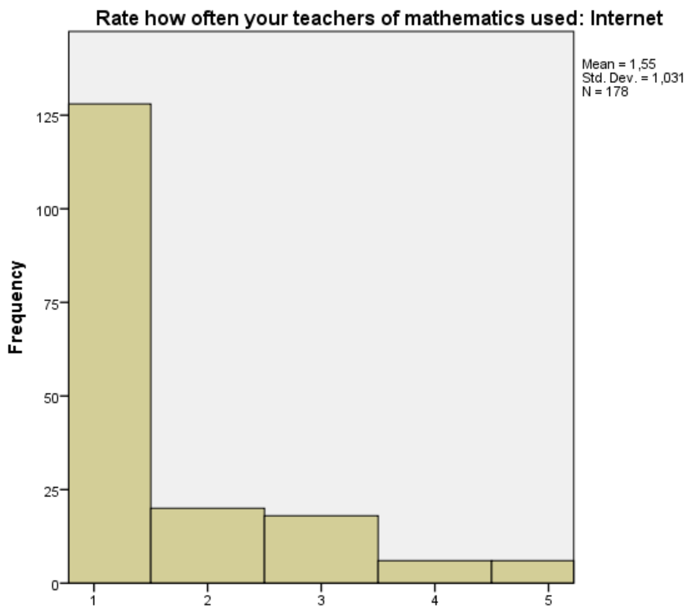


Figure 3.83: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

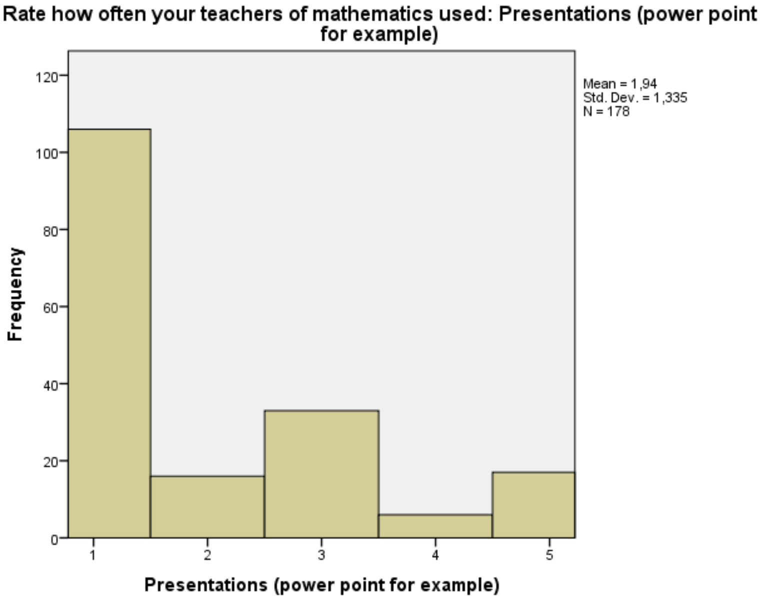


Figure 3.84: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

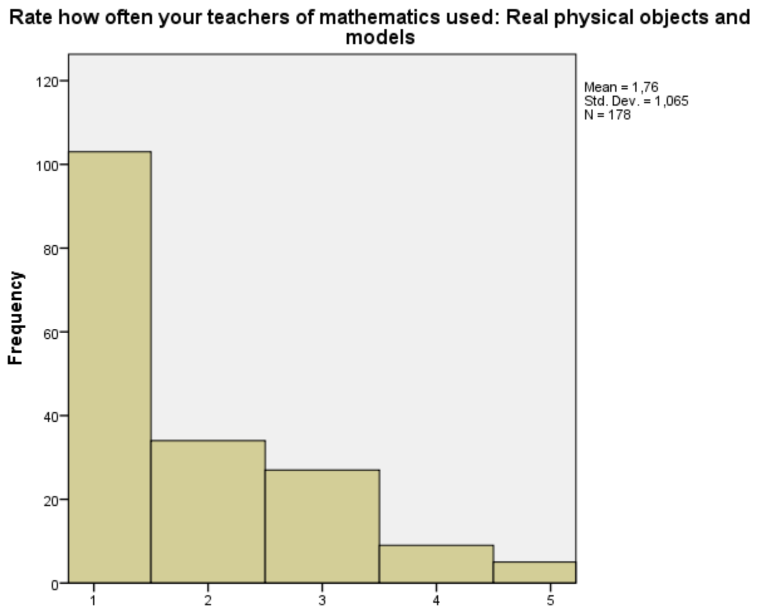


Figure 3.85: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

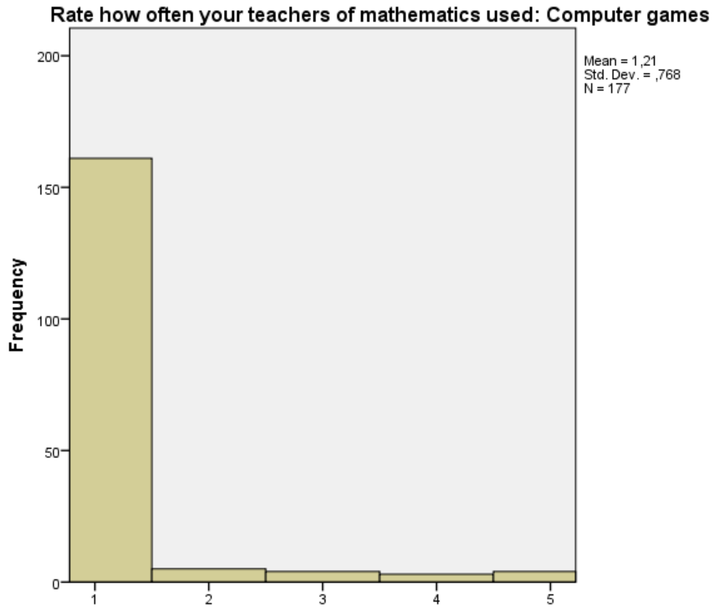


Figure 3.86: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

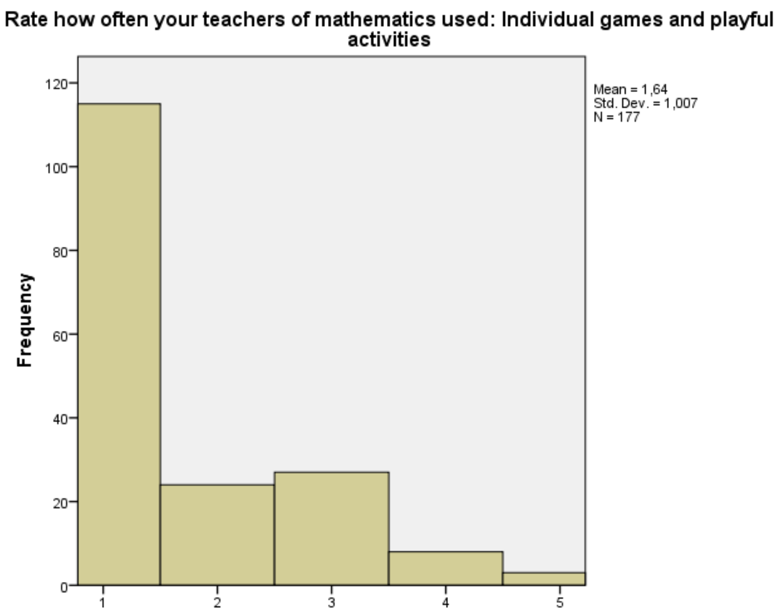


Figure 3.87: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

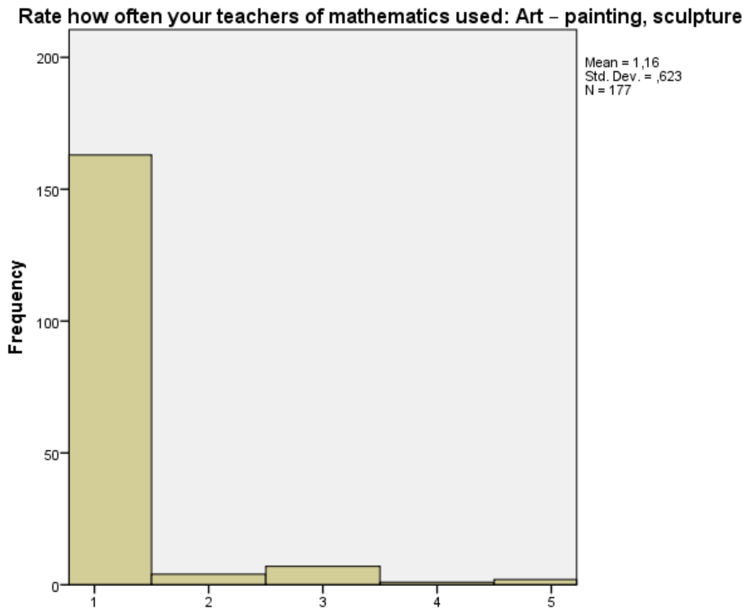


Figure 3.88: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

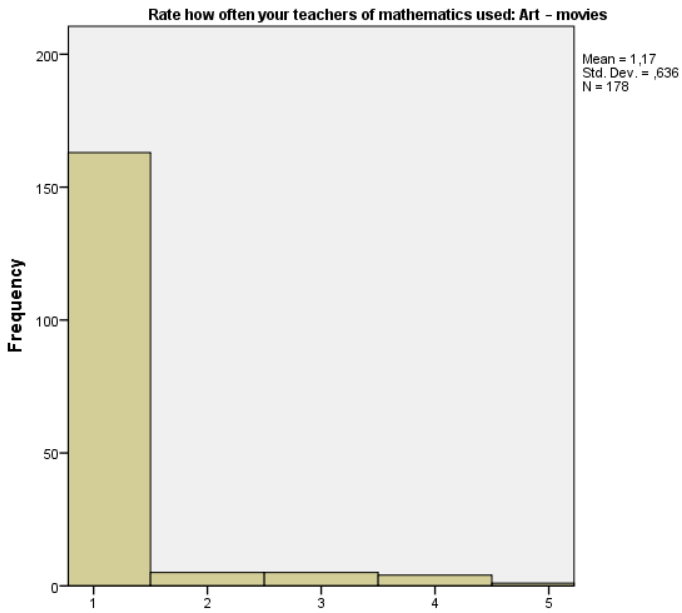


Figure 3.89: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

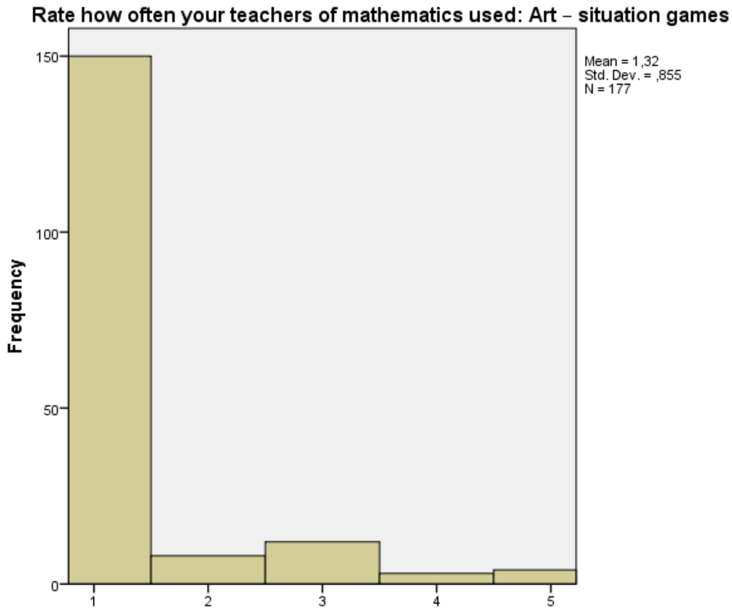


Figure 3.90: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

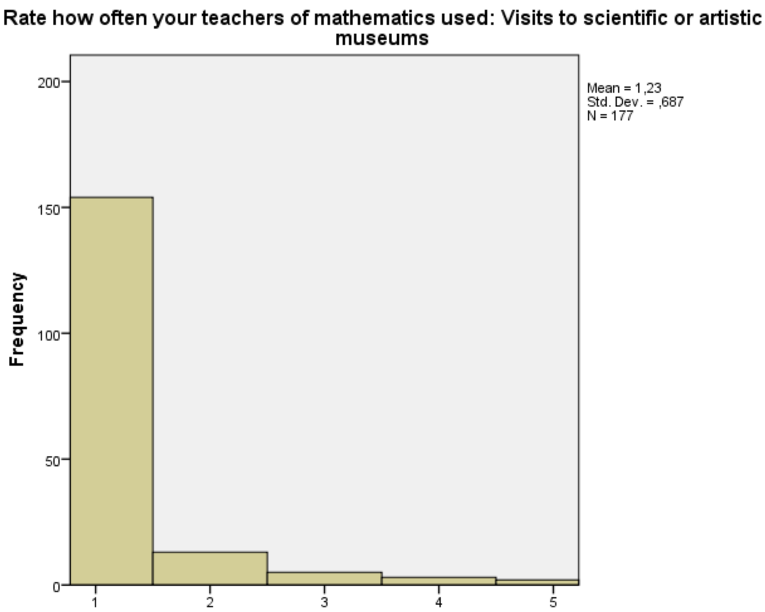


Figure 3.91: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

By contrast, the teachers seem to be much more successful in including different kinds of narratives or episodes from the history of science to illustrate mathematical problems in classes: approximately half of students experienced this regularly or at least sometimes (Figure 3.92).

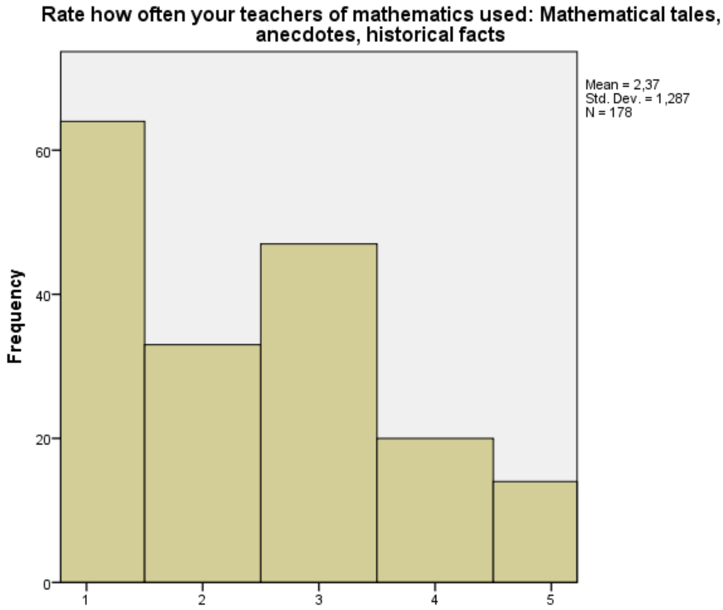


Figure 3.92: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

Taking all of this into account, we have to see as a positive factor, that a shade more than a half of the students occasionally worked in groups and took part in playful activities in mathematics classes (Figure 3.93). But approximately only a fifth of them engaged in individual playful activities regularly or at least sometimes in mathematics classes. Most of the students never took part in role-plays or in any education related outdoor activities during their mathematics classes (Figure 3.94).

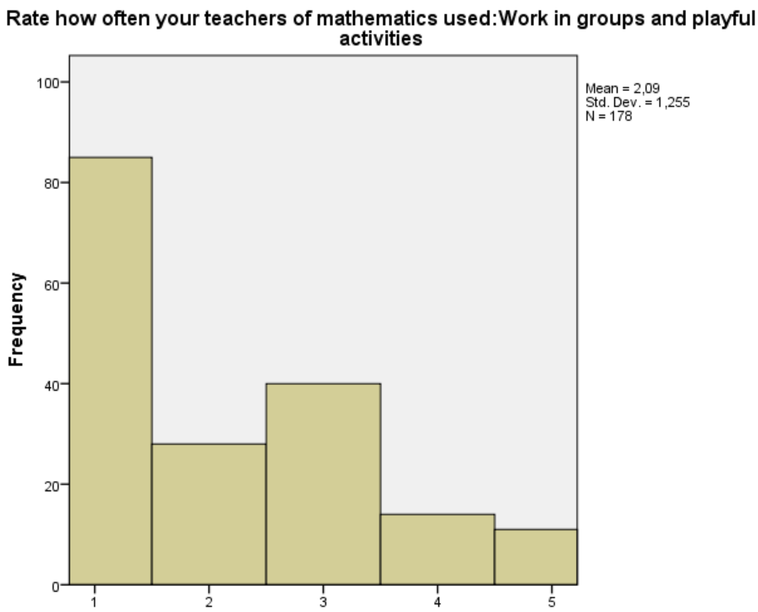


Figure 3.93: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

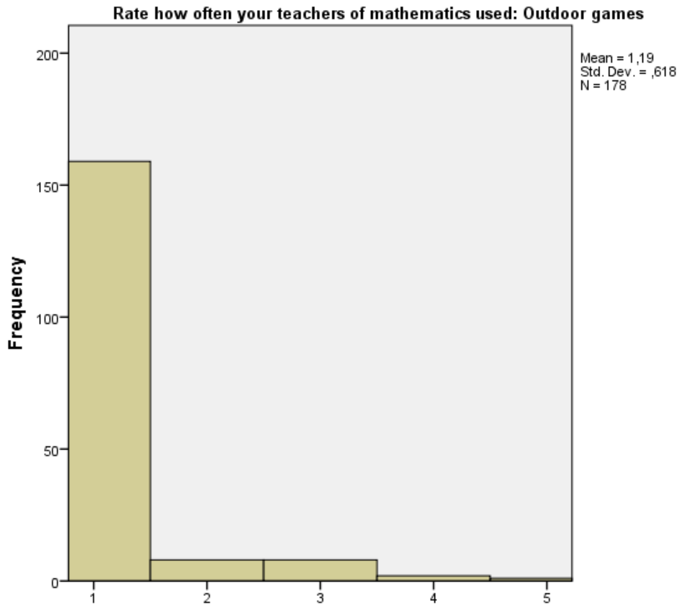


Figure 3.94: 1- Never, 2-, Rarely, 3- Sometimes, 4-, Often, 5- Always

3.4.5 Cross Tabulations for Serbian Students over 18 Years of Age

Compared with younger age groups, teaching methods still count a lot, but play a smaller role in higher education than in elementary and secondary level. In higher education, students' autonomy grows and they work more independently from their teachers, therefore they are much less exposed to the teaching methods. But we still managed to identify several points of connection between student attitudes and the teaching methods in higher education as:

- Students who were exposed to more varied teaching methods are more likely to think that mathematics is the most important course in school.
- Students were more optimistic regarding the career opportunities provided by mathematics learning in those groups where more teaching methods were applied.
- In accordance with this, students with more teaching methods, are more likely to disagree with the claim of "Mathematics was a complete waste of time".
- Students who experienced more varied teaching methods were less likely to be bored in their mathematics classes.

3.4.6 Gender Differences in the Answers of Students over 18 Years of Age

Although, gender differences seem to be less apparent in the group of students over 18 years of age, we did find some gender-related patterns in the answers, which are worth comparing with the answers of the students less than 18 years of age:

- In the group of students over 18 years of age, more males feel that they have not learnt a lot of mathematics during their education. This experience did not show any dependence on gender in the answers of students less than 18 years of age.
- In the group of students over 18 years of age, females get better grades in mathematics, just like those in the group of students under 18 years of age.
- Female students spend more time on their homework in both age groups.
- Females are happier with their grades.

Chapter 4

Conclusions and Recommendations Based on 2013 Survey Results

Given our results we can draw a few main conclusions about the initial indicators. The STATUS of mathematics has two main characteristics:

- It is important and valuable, but dry and boring
- It has no connection to real life and other domains of culture like the arts

The *USAGE* is surprisingly not experienced differently for either average children or future professionals:

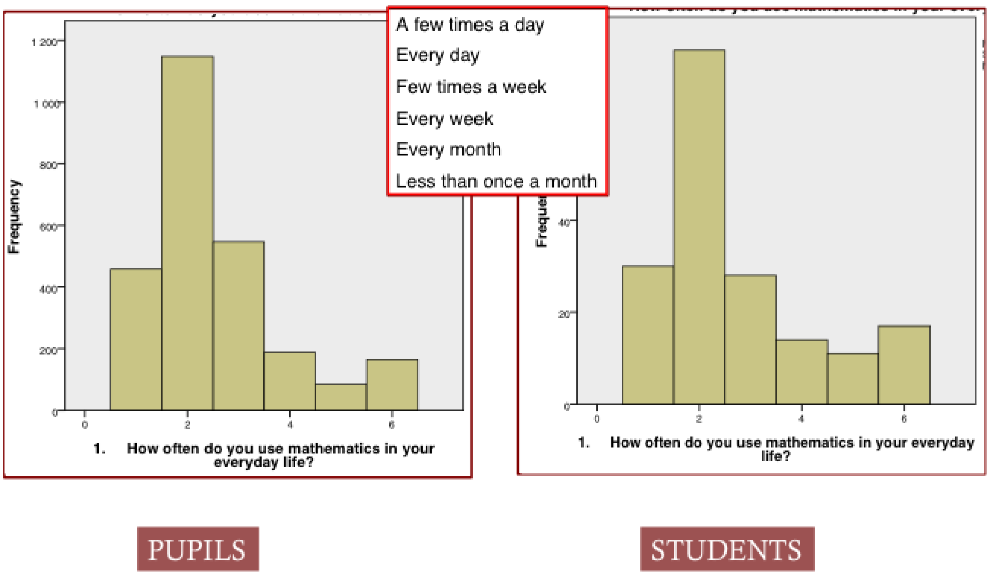


Figure 4.1

The *IMPORTANCE* shows expected results in which future professionals tend to group their opinion around higher values:

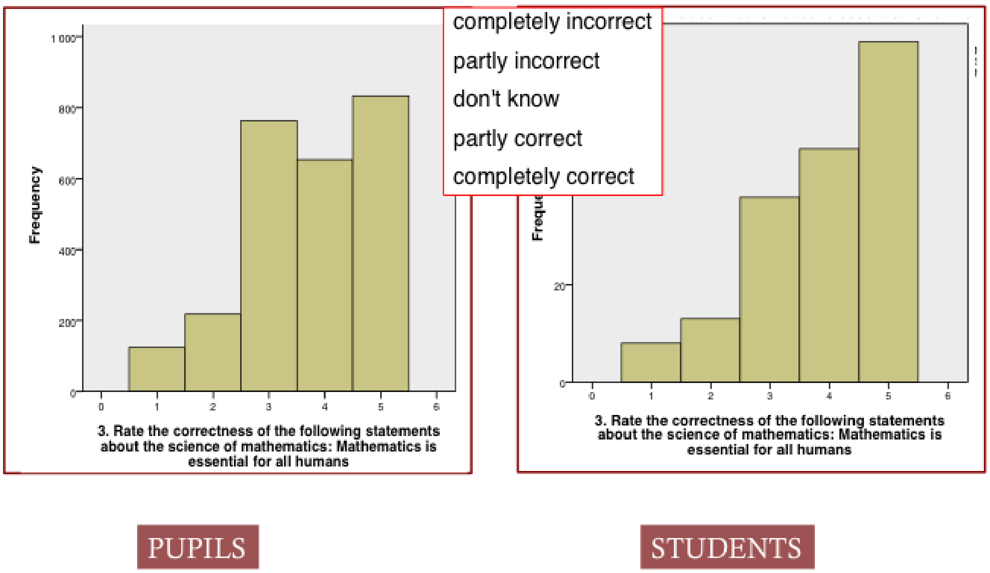


Figure 4.2

Also they find mathematics less *DIFFICULT* than the general population.

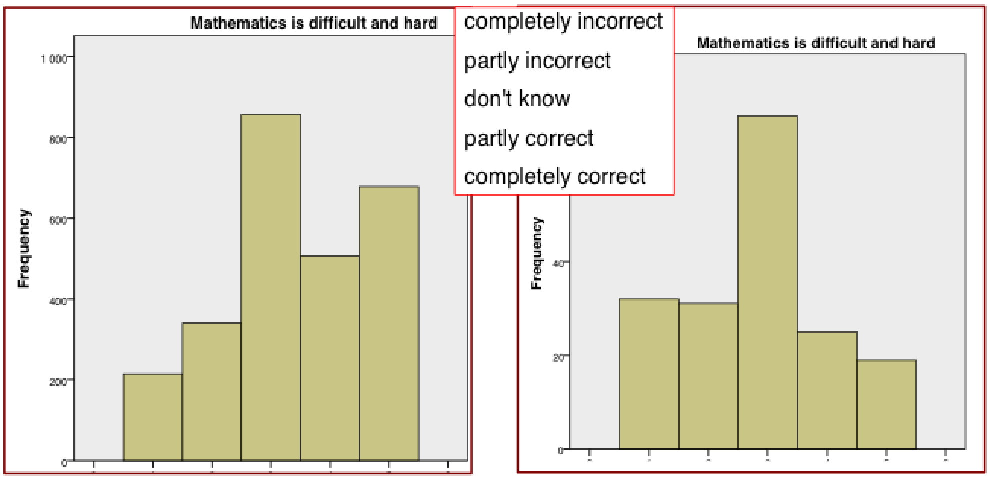


Figure 4.3

When it comes to mathematics and *REAL LIFE* there is no difference in opinions: mathematics is important for a future career:

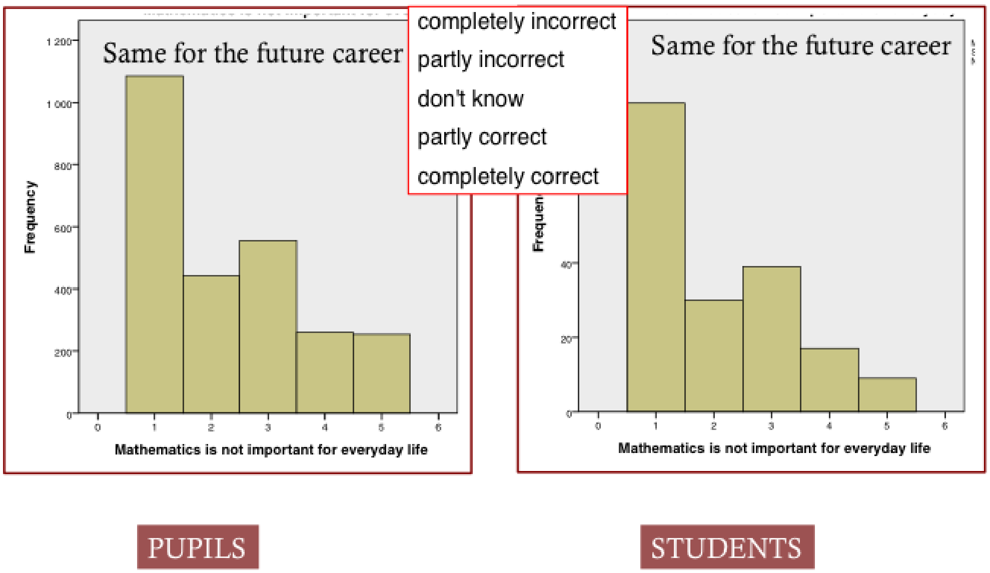


Figure 4.4

For us it was most surprising to find that there is no difference between the general population and future professionals when it comes to the *APPEARANCE* of mathematics: these graphs represent how boring mathematics is thought to be, but the same results were obtained for mathematics taught in school, in their school, by their particular teachers. Most participants think that it is completely correct to view mathematics as boring.

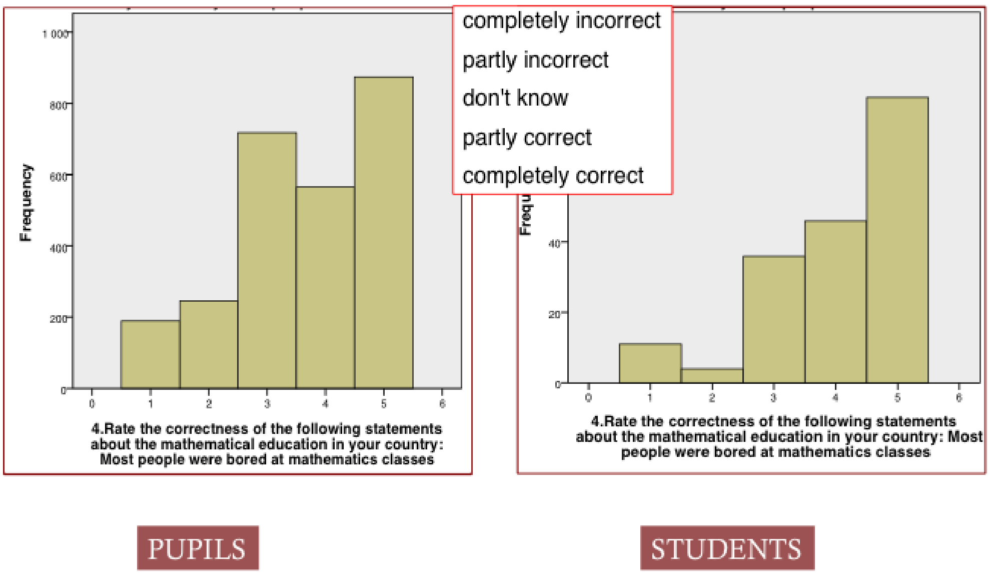
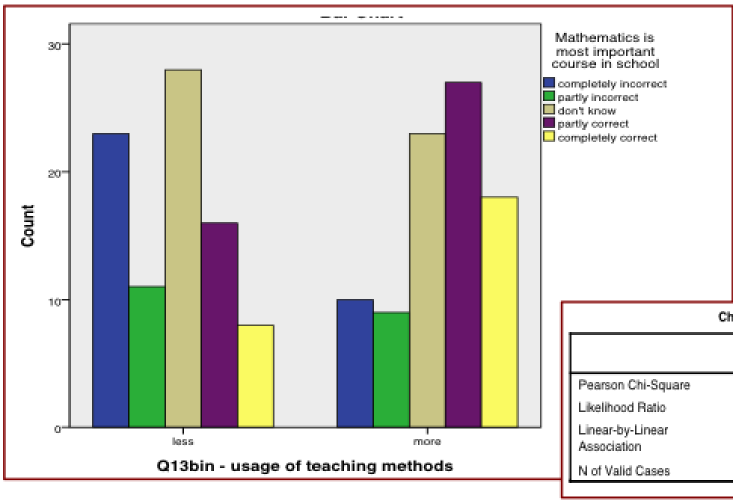


Figure 4.5

There is also a statistical difference in students' and pupils' view about the role of *TEACHING* mathematics in school.

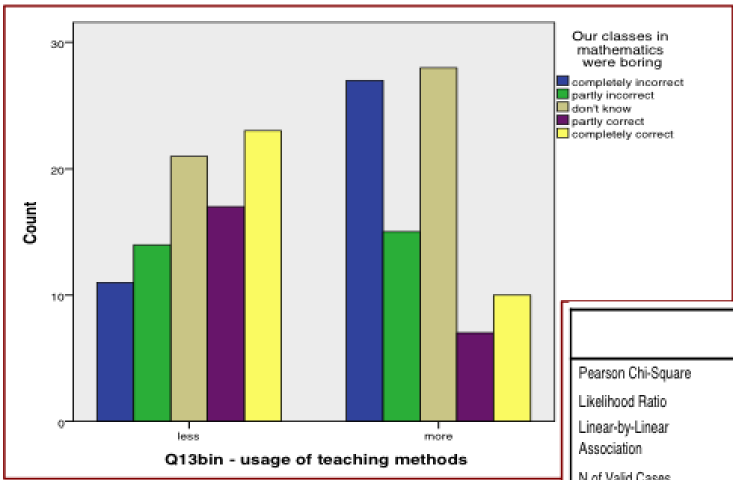


Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12,466[a]	4	,014
Likelihood Ratio	12,741	4	,013
Linear-by-Linear Association	11,573	1	,001
N of Valid Cases	173		

Figure 4.6

Finally, the introduction of various *METHODS* creates statistically significant differences in the perceived 'interestingness' of mathematics.



	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17,054[a]	4	* ,002
Likelihood Ratio	17,543	4	,002
Linear-by-Linear Association	14,065	1	,000
N of Valid Cases	173		

Q13bin - usage of teaching methods * Our classes in mathematics were boring

Figure 4.7

This is very important and encouraging as it tells us that the way mathematics is thought of can change the way mathematics is being experienced. It does not necessarily have to be boring and hard. Inclusion of art and references to other cultural domains might be a way of bringing mathematics closer to students.

One of the most important conclusions to be drawn from our analysis is that it is not certain that the core content of mathematics education needs to be changed, but it is the educational framework and the way of teaching mathematics. Our survey has demonstrated that mathematical knowledge is highly valued by the students and they have a great confidence in their mathematics education and teachers in school, but the way mathematics is presented is problematic for them. As cross tabulations have shown, there is a strong correlation between the variety of teaching methods, tools and cultural connections employed by the teachers and the students' attitudes towards the subject. Therefore we think that the methodological set of mathematics teaching should be broadened in order to develop students' attitudes toward mathematics.

According to the survey, most of the teachers base their activity on an extremely limited set of educational tools, materials and methods; therefore mathematics education in schools has a monotonous nature. Students find mathematics classes boring and their education does not inform them about the cultural embeddedness of mathematics. It does not connect to their daily reality and also does not provide them with all those technical tools, visual models, hands-on materials and cultural information which could make mathematics classes more entertaining by involving students creatively. It also does not build sufficiently on contents, methods and equipment which might help students to discover mathematics-related contents in their everyday environment, and experience mathematical knowledge as an integral part of their culture. Therefore students are not informed to a sufficient level about mathematical connections with other cultural domains (such as art, design, architecture, music, dance, etc.) and with the context of real life situations and problems.

As games and game-like activities seem to have a favorable effect on attitudes towards math education[1], and as there are several studies demonstrating the positive impact of math games in education , there is a basis for recommending an increase in the use of math games in both secondary and tertiary education. There are, however, caveats and a clear indication that math games do not automatically improve attitudes towards math education or the learning outcome[2]. As with all novelties in the classroom, there is a need to develop the pedagogical approach accordingly, so that the new tools (math games in this case) may be seamlessly integrated into the curriculum, and their potential be fully realized. It is also worth noting that according to our survey, only a small fraction of the Serbian math classes have computers or other such devices (like tablets) available, and therefore it is not possible to introduce digital math games in many places.

It is thus desirable that the main impetus is targeted towards teacher education, where the pedagogical potential of math games should be incorporated into the studies, with related research activities to ensure the approach is best suited to the Serbian conditions. Instead of strictly focusing on digital math games, it should prove more fruitful to adopt a wider approach to playful and game-like activities, which may not require technological devices at all and which may be connected to other experiential approaches advocated in this report. In the secondary school level, it is important to provide support and encouragement for those teachers who are interested in employing math games in their classes. This support could be provided, for example, as informal peer groups.

The school that is built upon the dogmatic segmentation of knowledge and the pedagogy of strictly fixed roles is no longer effective today. Many students of today will have jobs that do not yet exist. The development of core competencies requires

[1] See for example: Sarama, J. & Clements, D. (2009) "Building blocks and cognitive building blocks: Playing to know the world mathematically", American Journal of Play, Winter 2009, 313–337.

[2] See especially: Bragg, L. (2007) "Students' conflicting attitudes towards games as a vehicle for learning mathematics: A methodological dilemma", Mathematics Education Research Journal, Vol. 19:1, pp. 29–44.

multi-modal flexibility that connects formal and informal environments of education and involves several variables of the learning process. All these tendencies prompt us to enlarge the set of didactical approaches, educational tools and materials of mathematics education in Serbian education with aesthetic, creative, playful, hands-on, and experience-based[3] components to complement the STEM with artistic contents, aesthetics and cultural aspects.[4]

As our survey and meetings with the teachers at the Tempus Summer Schools has shown, a great number of experience-centered and playful tools and approaches are available for the enhancement of mathematics education and there is also a need for a much greaterbetter involvement of the schools' local environment (schoolyard, local museums, cinema, library and other cultural institutions and facilities, etc.) into mathematics education. To map and include cultural connection contents of mathematics into the mathematics classes beside their own research, teachers can also cooperate with their art, history, literature, music and , physical education activities teacher colleagues and with the teachers of other sciences. As parents also proved to be a valuable support in the forming of attitudes towards mathematics, new forms of cooperation with the parents also can also be sought by the teachers.

Credits: The Tempus Project team owe thanks to Teemu Holopainen for the statistical analysis and for producing the graphs for the Tempus Attitude Survey (TAS) 2013.

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[4]Darvas, Gy., Fenyvesi, K. (2014), Symmetry Festivals in the Classroom! The Hungarian Experience Workshop Movement in the Education of Mathematics and Symmetry Studies through Arts, Proceedings of the 12th International Conference of The Mathematics Education into the 21st Century Project, Herceg Novi.

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Chapter 5

Tempus Attitude Survey 2014

Ruth Mateus-Berr (UAAK)
Klelija Zivkovic (UAAK)
Lilijana Radovic (MISANU)

Data was collected by Jelena Samardzic Metropolitan University Belgrade (BMU), supervised by Suncica Zdravkovic (UNS).

The data collection was transferred to Klelija Zivkovic (UAAK).

Graph Interpretation, Evaluation and Conclusion by Ruth Mateus-Berr & Klelija Zivkovic University of Applied Arts Vienna (UAAK) in Cooperation with Lilijana Radovic (Mathematical Institute of the Serbian Academy of Sciences and Arts - MISANU).

5.1 Introduction

5.1.1 The Questionnaire and the Research Methods

The same questionnaire (Appendix) from 2013 was used in the spring of 2014. A sample of students, some of who will become future professionals (mathematic teachers, graphic designers, ICT professionals, architects, etc.) and a sample of the student population from elementary and secondary high schools, taught by math teachers who attended the Summer School in Eger 2013 were interviewed.

5.1.2 Locations of Survey

Districts: Beograd, Obrenovac, Kovin, Lazarevac, Ruma, Ub, Inđija, Zemun, Niš, Pančevo, Zemun, Pećinci, Stara Pazova, Ruski Krstur, Bačka Palanka, Kula, Senta, Bečej, Novi Sad, Bačka Topola.

Schools: 8 elementary schools, 22 high schools (Gymnasium, Technical, Mechanical and Electro-technical high school,) and students from 4 universities (BMU, ICT, UNS and MISANU) participated in the survey.

University: 92 students from BMU, 4 from ICT, 15 from UNS and 9 from MISANU (1 missing).

5.2 Data Collection

The 2014 data collection was executed in the same manner as in 2013. University and high school students took the survey using a web-based questionnaire, while elementary students in the schools completed a paper and pencil questionnaire. Students were required to read the statements and to indicate the extent of their agreement on the basis of the options provided on a 5-point Likert scale: completely incorrect, incorrect, neutral, correct, completely correct; or with regards to frequency: a few times a day, every day, few times a week, every week, every month, less than once a month or never, rarely, sometimes, often, always The statements were formulated by Suncica Zdravkovic and Kristof Fenyvesi.

The data in this study are analyzed using IBM SPSS Statistics v.21m.

Due to the flood in Serbia, the school semester was interrupted, and ended 3 weeks later than usual. Therefore the data collection was postponed accordingly.

5.3 Data Analysis / Previous Studies and Tempus Survey 2014

TIMSS (Trends in International Mathematics and Science Study) 2007 and 2011 examined “general attitudes toward mathematics of students, the value they place on mathematics as a way of improving their lives and their self-confidence (SCM) in learning mathematics” and created an “Index of Students’ Positive Affect Towards Mathematics” (PATM), based on questions like “I enjoy learning mathematics”, “Mathematics is boring” and “I like mathematics” (Mullis et al. 2008, 185; Mullis et al. 2012, 31-33). Students who agreed a little or a lot on average with all three statements were assigned to the high level index and therefore were counted as having a positive attitude towards mathematics and those who disagreed were interpreted as the opposite. Across countries having a high level index, students had higher average mathematics achievement (comp. Mullis et al. 2008) and students who did not like learning mathematics had the lowest achievements (comp. Mullis et al. 2012). For this reason a bidirectional relationship between attitude, self-confidence and achievement is assumed (Mullis et al. 2008, 186; Mullis et al. 2012, 31). Further on TIMSS (2007, 2011) analyzed what value students have for mathematics (SVM) with questions like: “I think learning mathematics will help me in my daily life”, “I need mathematics to learn other school subjects”, “I need to do well in mathematics to get into the university of my choice”, “I need to do well in mathematics to get the job I want”. It was assumed that if children have high SVM that they are more attracted and motivated to learn mathematics.

“Internationally, the nearly one-half of students that Value mathematics (SVM) had the highest average achievement, followed by those that Somewhat Value the subject. Those that Do Not Value mathematics (15%) had the lowest average achievement” (Mullis et al. 2012, 33). In 2007 Serbia (Mullis et al. 2008, 188) achieved: 518 (4.3) – compared to international average achievement of 471 (0,6) of high PATM and 499 (5.7) – compared to international average achievement of 441 (0.7). Students lacking confidence (SVM) (21%) had the lowest achievement (Mullis et al. 2012, 32). In TEMPUS 2014 survey similar approaches were used (chapter

1.4. A.IV). TIMSS (2011, 33-35) collected information about students engagement in learning, which focuses on the cognitive interaction between the student and the instructional content. To measure aspects of student engagement, students and teachers attitudes were analyzed. In the TEMPUS 2014 survey similar approaches were used (chapter 1.4.A.V and 1.4.C., 1.4.D). The claim for each students' individual approach and support, accompanied by the need of application and production of new learning tools and strategies go hand in hand with such audits as TIMSS. Instructional content ("what") was analyzed by strategy ("how"), teachers were asked to report how frequently they use various instruction activities and strategies, but "researchers are beginning to understand these lists of activities cannot be used as proxies for the characteristics of good teaching" (Mullis et al. 2012, 370). According to the importance of student content engagement (McLaughlin et al. 2005) focus was placed on interaction between student and instructional content because "student content engagement focuses on the importance of the activity that brings the student and the subject matter content together" (Mullis et al. 2012, 370). Aslan et al. (2013, 46) remind us that there can be considered at least "three main philosophical conceptions of mathematics as instrumentalist, Platonist and problem solving. Instrumentalist view proposed that mathematics consists of particular operation, rules and skills. Platonist view suggested, that "mathematics is a static but unified body of certain rules". And in the problem solving view mathematics is a dynamic and cultural production that always improves with invention".

Further, it must be discussed if constructivist approaches (in the sense of philosophy and education) – which are the basis of artistic research and strategies- in mathematics would change the involvement of the students, as particularly in subjects where only one solution is considered correct and there are no other solution strategies possible, engagement will decrease.

Besides evaluating whether teachers summarize the lesson's learning goals, we also examined whether teachers managed to relate lesson content to students' daily lives, and the form of personal feedback to students, the results can be found in the analysis of "bringing interesting material to class" (Mullis et al. 2012, 371). "Many fourth grade students, 69 percent on average, internationally, had mathematics teachers that made efforts to engage them in instruction by using a variety of strategies in *Most Lessons*, and most of the remaining students had teachers that used engaging instructional practices in *About Half the Lessons* (with a few exceptions). Across the fourth grade, sixth grade, and benchmarking participants, students often had slightly higher average mathematics achievement if their teachers used engaging instruction in *Most Lessons* rather than *About Half the Lessons*" (Mullis et al. 2012, 371). In Serbia teachers were described to use *Most Lessons* diverse instructional practices, which led to an achievement of 517 (3.5) – compared to an international average of 492 (0.6), and *About Half the Lessons* which led to an achievement of 512 (6.0) compared to an international average of 488 (1.0) (Mullis et al. 2012, 376).

TIMSS also proved that collaboration between staff improves teaching results (Mullis et al. 2012, 357). In Serbia teachers were considered to be very collaborative which led to an achievement of 523 (3.7) – compared to an international average of 493 (0,9), and collaborative which led to an achievement of 508 (4.6) compared to an international average of 491 (0.7) (Mullis et al. 2012, 372). In the TEMPUS 2014 survey similar approaches regarding teaching strategies and collaboration were used (chapter 1.4.C 1.4.D).

In 2011 Serbia achieved 516 (3.0) in mathematics, which is significantly higher than the Center-point of the TIMSS 4th grade scale (Mullis et al. 2012, 52).

The survey of 2014 has been analyzed through five domains: Pupils, Parental Homes, Teaching, Teachers and University Students.

5.3.1 Pupils

5.3.1.1 Demographic Information

Altogether there were 1211 pupils (607 female/602 male, 2 missing), 290 from elementary and 917 from high school. The biggest survey group was pupils between 15-17 years. Most of them live in a city (64,7%), nearly half as many (35%) in villages.

A note on terminology: We use the term "elementary school" as in Serbia elementary school is for children from 6 to 14 years old (which would correspond, for example, in Austria with primary school for 6-10 year olds, and secondary 1: for 10-14 year olds) and we use the term "high school" because in Serbia high school is for 15-18 (19) year olds (which would, for example, correspond in Austria with secondary 2: for 14-18 year olds).

The biggest survey group was children between 15 and 17 years of age, scholars of secondary 2 (Figure 5.1). There were 607 female and 602 male participants (missing 2) (Figure 5.2). Most of them live in a city (64,7%), nearly half as many (35%) in villages. (Figure 5.3).

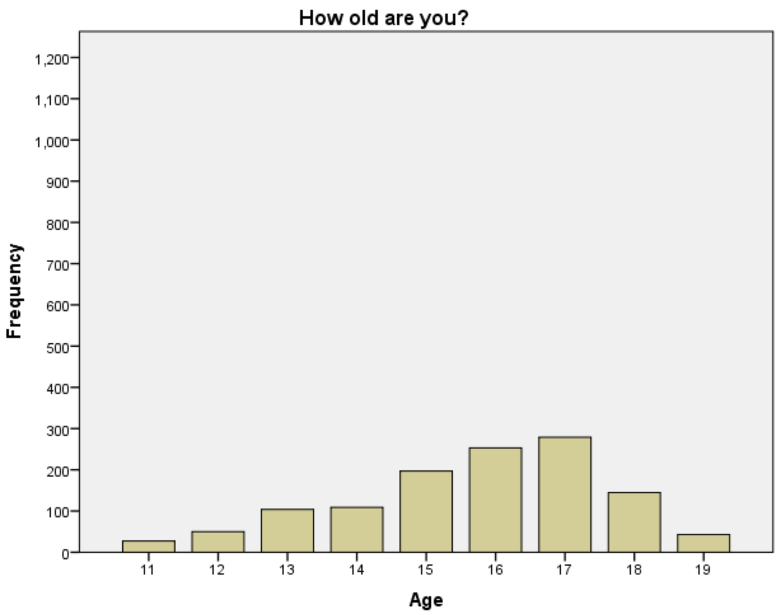

Figure 5.1: Age (Source: Klelija Zivkovic)

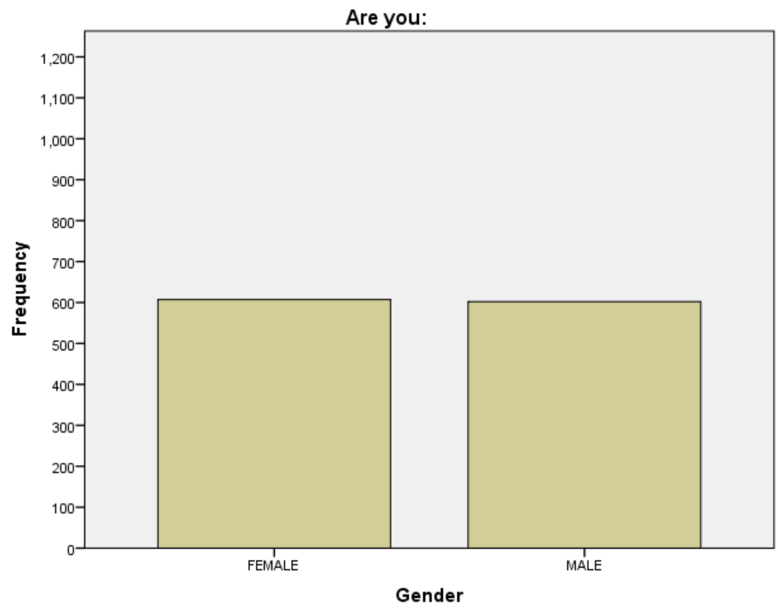

Figure 5.2: Gender (Source: Klelija Zivkovic)

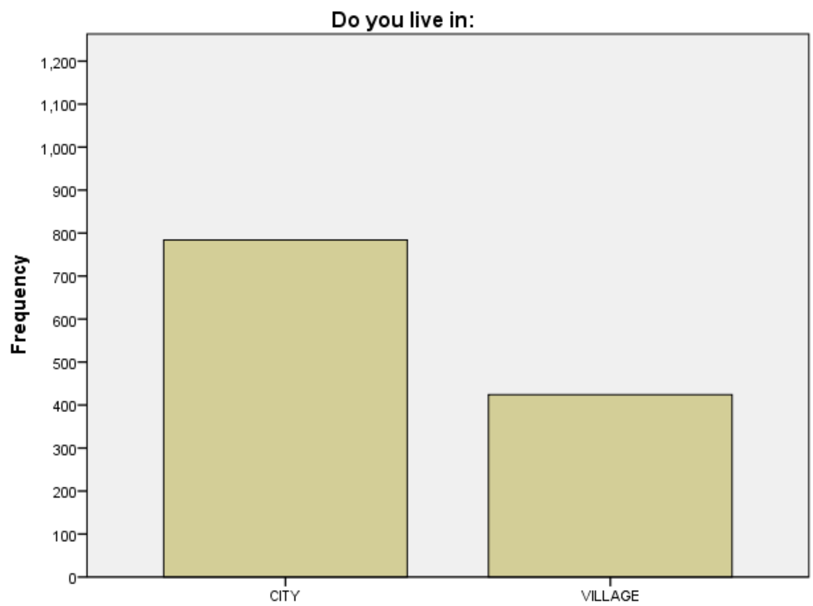

Figure 5.3: Environment (Source: Klelija Zivkovic)

5.3.1.2 Grades

A very small percentage (less than 5%) failed in math in 2013, whereas the rest alternated between good and satisfying (Figure 5.4). Most of the children had average grades between 3-4 (399 pupils) and 4-5 (462 pupils). Nearly half of them (227 pupils) had an average grade between 2-3. When comparing gender and math grades, a couple of observations can be made: more girls failed (grade 1) than boys did. More boys achieved grades 2 and 3, while in the higher grades the girls slightly surpass the percentage of the boys (Figure 5.6).

Grades in elementary and high school in Serbia are from 1-5, where the best is 5 and the worst 1. No one can go to second level with average grades less than 2. So the main focus was on a target group which can be considered as made up of above average students in mathematics.

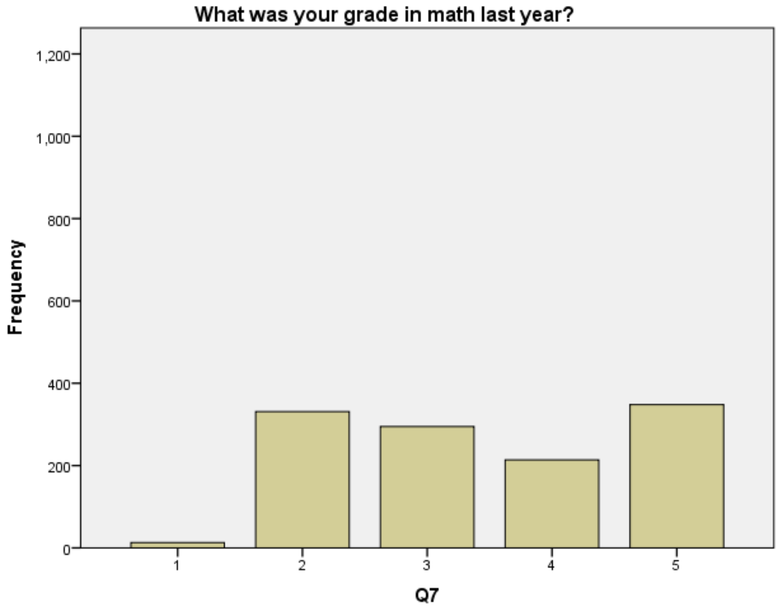

Figure 5.4: Math Grades (Source: Klelija Zivkovic)

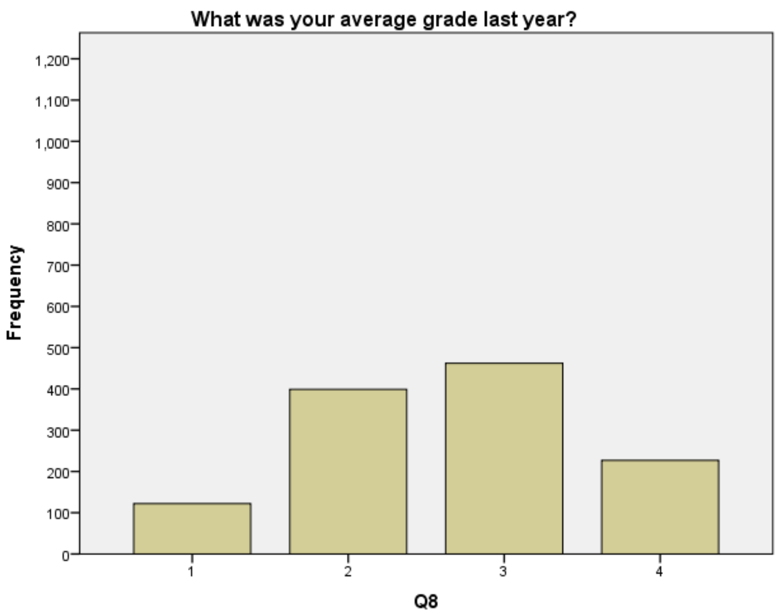

Figure 5.5: Average Math Grades (Source: Klelija Zivkovic)

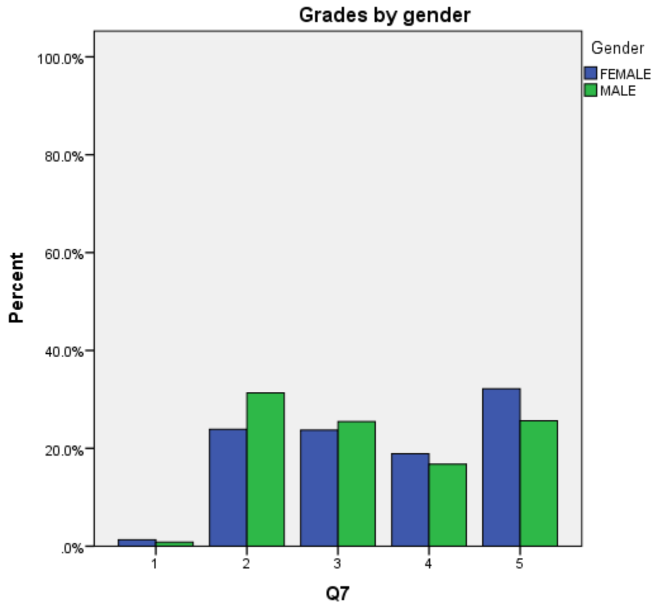

Figure 5.6: Math Grade & Gender (Source: Klelija Zivkovic)

5.3.1.3 Studying

About 29% of the respondents stated that they study math less than once a week, 26% said they study once a week, 25% said they study 2-3 times a week and 9,4% said they study every day (Figure 5.7).

Most of the pupils (around 37%) reported studying math at home for around an hour, around 22% said they study for just around 15 minutes. Around 27% study less than an hour, whereas only 1.2% studied for more than two hours (Figure 5.8).

37% pupils claimed that they took extra math classes, almost 12% took extra classes a few times and around 6% took extra math classes all the time. Just over 45% didn't need any extra math classes. Around 35,3% stated that they have had no continuous help with mathematics homework, whereas about 23% were undecided. Last but not least, almost 41,4% answered that they did need help with their homework (Figure 5.9).

In Serbia teachers have an obligation to offer a weekly extra class to less-able students and to those who are gifted at mathematics. Despite this, many students also have to take extra paid classes: half of the interviewed students seemed to need to pay for private classes in mathematics.

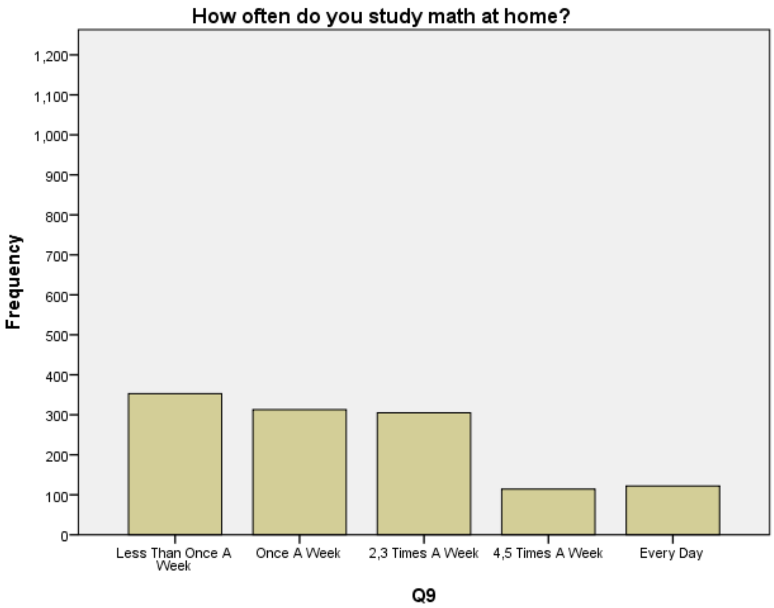

Figure 5.7: Math Study Quantity (Source: Klelija Zivkovic)

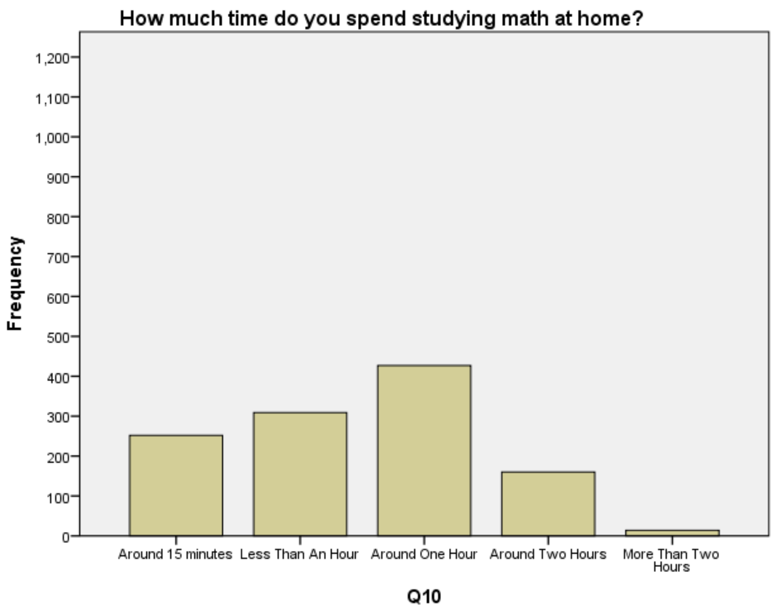

Figure 5.8: Math Study Time (Source: Klelija Zivkovic)

Figure 5.9: Somebody always helped me with my homework in mathematics (Source: Klelija Zivkovic)

Figure 5.10: Taking extra math classes (Source: Klelija Zivkovic)

	Less than once a week	Once a week	2,3 times a week	2,3 times a week	Every day
How often do you study math at home?	29,2%	25,9%	25,3%	9,4%	10,1%
	Around 15 minutes	Less than an hour	Around one hour	Around two hours	More than Two hours
How much time did you spend studying math at home?	21,7%	26,6%	36,7%	13,8%	1,2%

Table 5.1: Summary Studying-Time (Source: Klelija Zivkovic, Ruth Mateus-Berr)

	No	Yes	A few times	All the time	
Did you ever take private math classes in your school or at home?	45,6%	37,1%	11,6%	5,7%	
	completely incorrect	incorrect	neutral	correct	completely correct
Somebody always helped me with my homework in mathematics	25,6%	9,8%	23,1%	13,9%	27,5%

Table 5.2: Extra math classes & homework help (Source: Klelija Zivkovic, Ruth Mateus-Berr)

5.3.1.4 Attitudes, Beliefs

The questions in this chapter refer to the value students place on mathematics (SVM). It was assumed that if children have a high SVM that they are more attracted and motivated to learn mathematics. Although these questions are to a high extent general, they allow us to develop an interpretation of students' attitude concerning values of mathematics. Asked about the essentiality of math for all humans, about 32% of people interviewed were undecided. However, mathematics was considered to be essential for all humans by 57% of those interviewed (Figure 5.11). 43,1% of the pupils consider math as difficult and hard, while 23% of the pupils think the opposite, 34% of the pupils remained undecided (Figure 5.12).

Most pupils, 75%, believe that math indeed does improve intelligence (Figure 5.13). About 62% of the pupils believe that math is important for everyday life. Conversely, 18,9% agree to the opposite statement that math is not important in everyday life, a similar number to the pupils who answered that they were undecided (19,9%) (Figure 5.14). 36,7% of pupils asked, agreed that math is the most important course in school, 29,2% disagreed (Figure 5.15). As students get older they become more certain in their belief that math is essential, and 36,7% believe that mathematics is the most important course in school (Figure 5.16). Most surveyed pupils (39%) were undecided as to whether mathematics would open doors for a future career. A similar proportion, 38,4% of the interviewed pupils, thought that math was important for their future careers. 22,6% of the pupils did not consider math an important asset for their future careers (Figure 5.17). Most pupils surveyed, 68,5%, think that the current amount of math taught in schools is adequate. In contrast, 10,5% agreed with the statement and felt that they need more mathematics instruction in their schools (Figure 5.18).

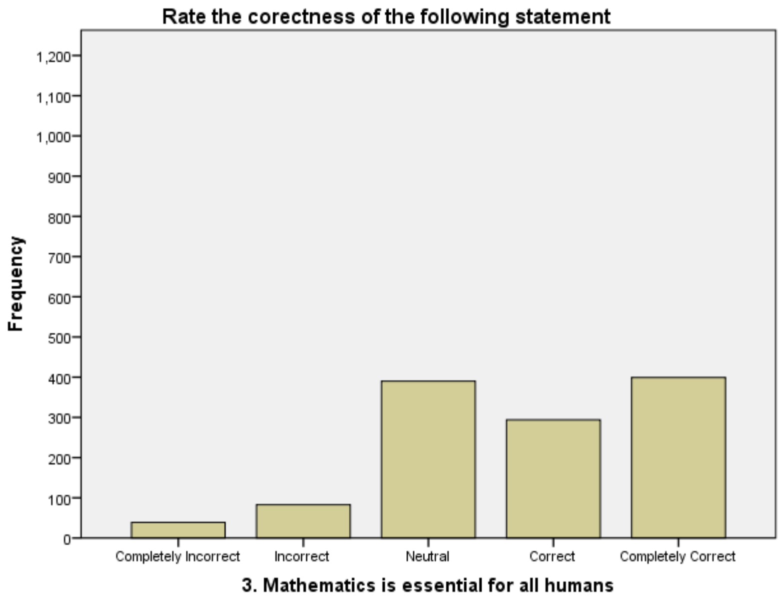

Figure 5.11: Mathematics is essential for all humans (Source: Klelija Zivkovic)

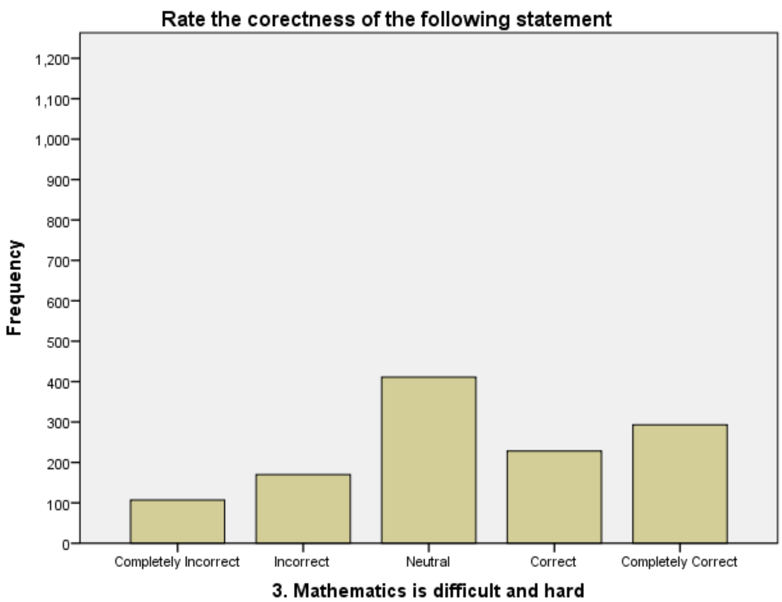

Figure 5.12: Mathematics is difficult and hard (Source: Klelija Zivkovic)

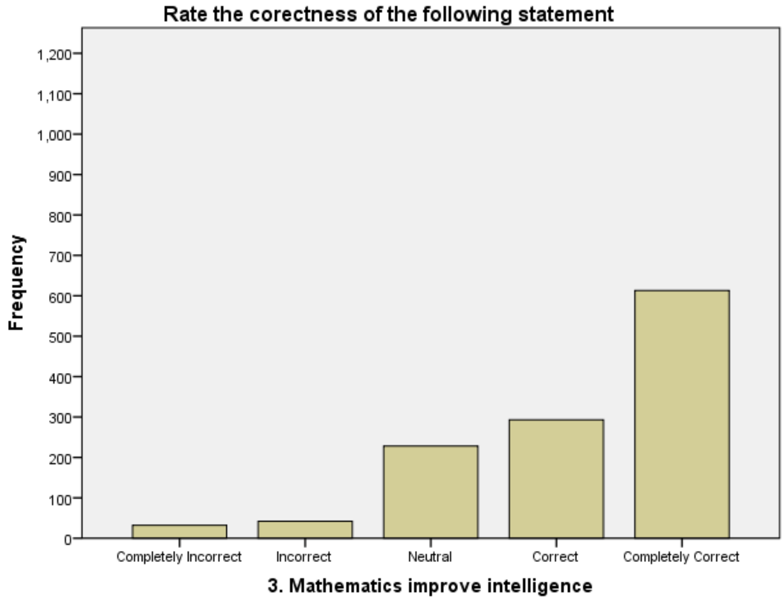

Figure 5.13: Mathematics is essential for all humans (Source: Klelija Zivkovic)

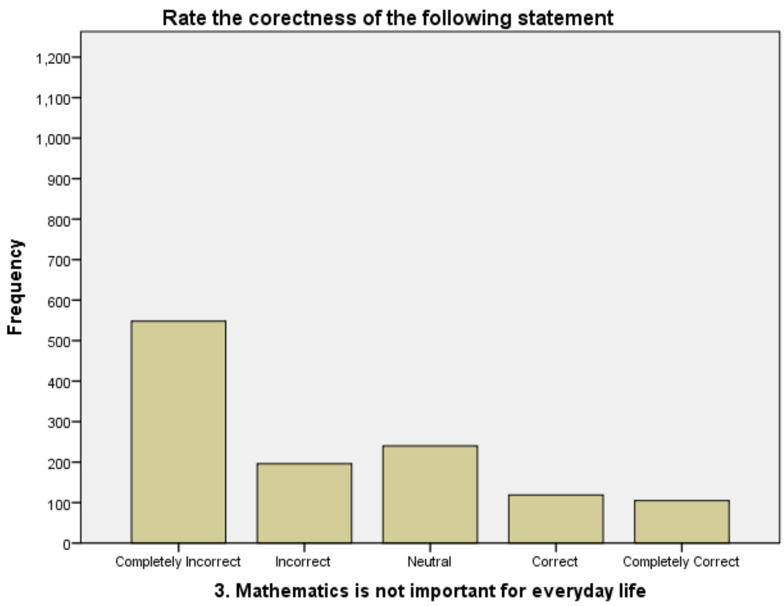

Figure 5.14: Mathematics is not important for everyday life (Source: Klelija Zivkovic)

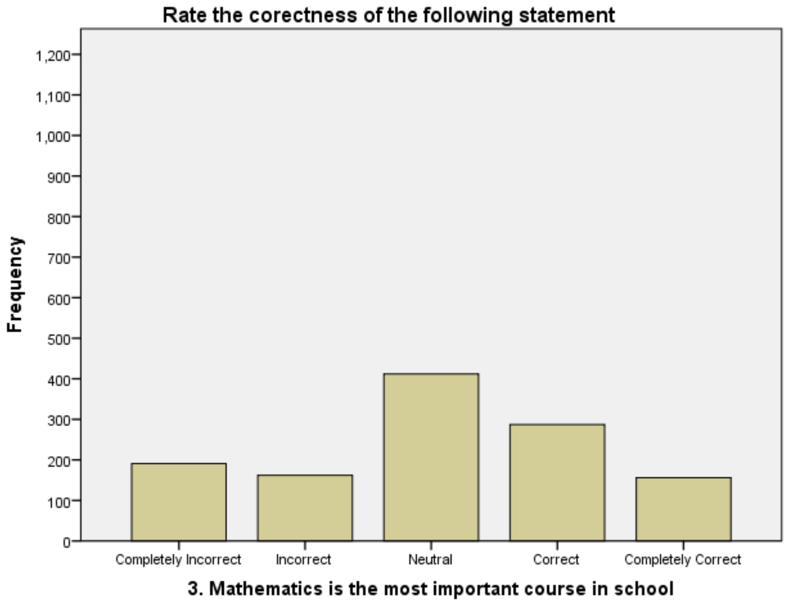

Figure 5.15: Mathematics is the most essential course in school
(Source: Klelija Zivkovic)

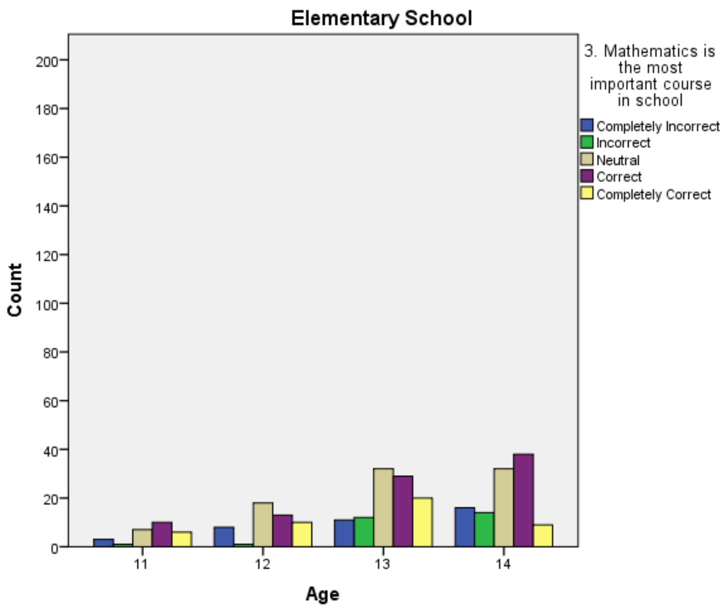

Figure 5.16: Mathematics is the most important course in school
(Source: Klelija Zivkovic)

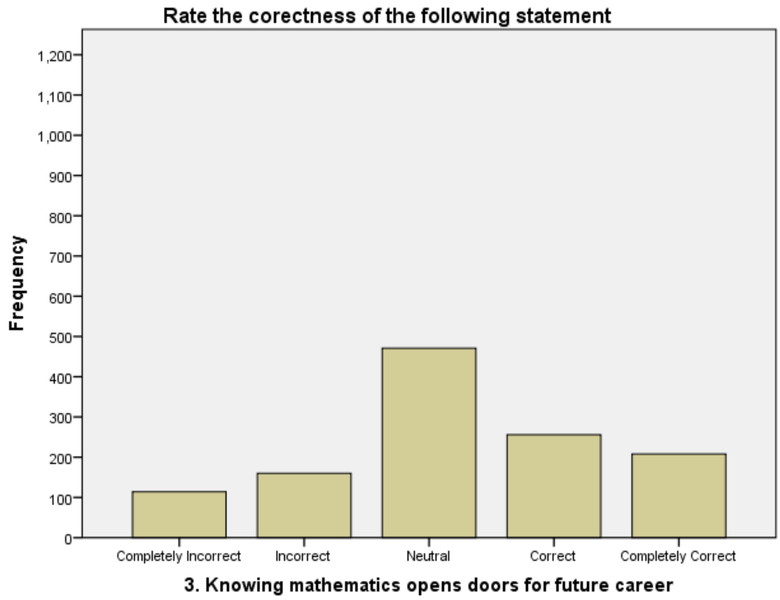

Figure 5.17: Mathematics opens doors to a future career
(Source: Klelija Zivkovic)

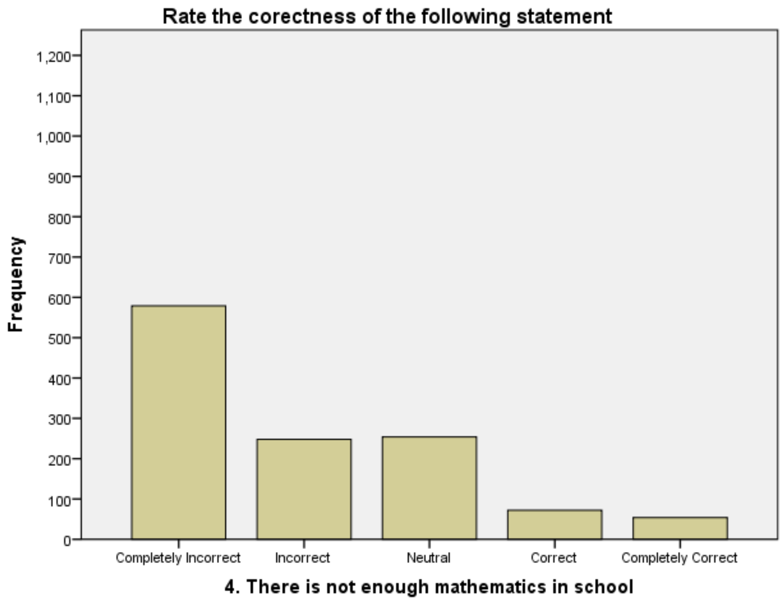

Figure 5.18: There is not enough Mathematics in school
(Source: Klelija Zivkovic)

The same proportion of pupils (29.7%) stated that math was not always easy for them as (30.2%) were undecided. About 12% stated that math was always easy for them (Figure 5.19). Close to 25% of the pupils are not happy with their grades in math, around 41% described themselves happy with their math grades and 23% seem to be indifferent (Figure 5.21).

Although about 30% of the students had difficulties in studying math, 24,4% needed help with homework (Figure 5.20) and more than a third were content with their grades.

About the same average who claimed that math was not always easy for them seemed to have no support with homework. Several studies (Mettas et al, 2006; Papanastasiou, 2002) illustrate a positive relationship between attitudes and achievements.

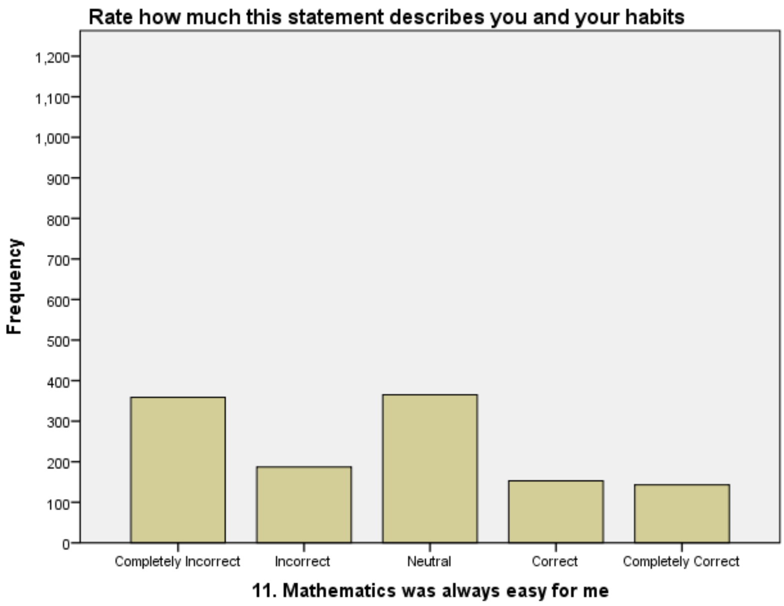

Figure 5.19: Mathematics was always easy for me (Source: Klelija Zivkovic)

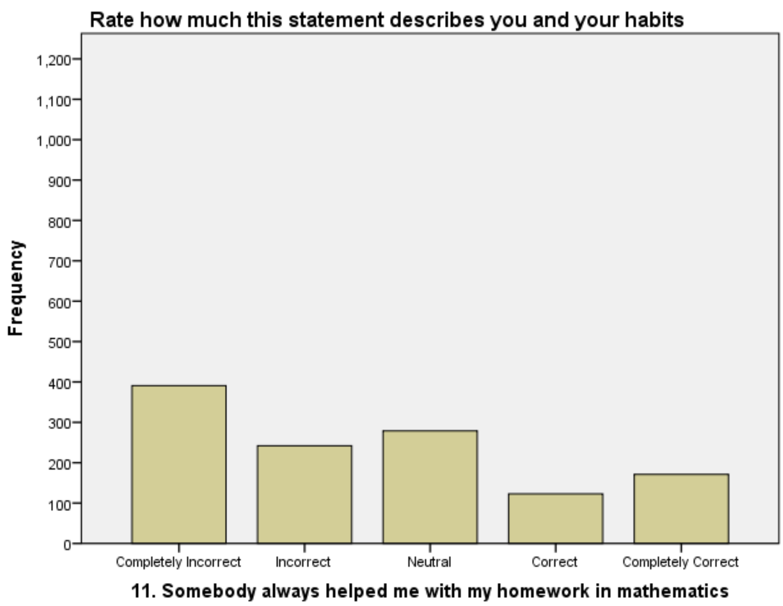

Figure 5.20: Help with homework (Source: Klelija Zivkovic)

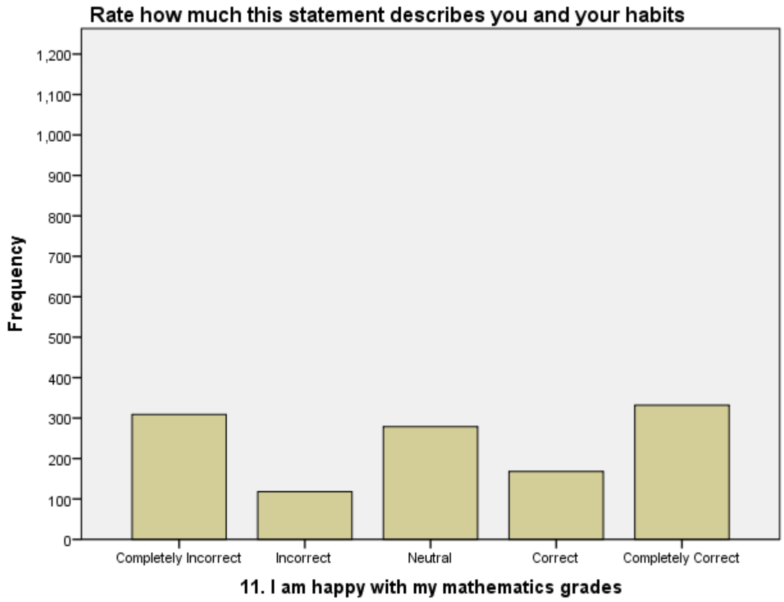

Figure 5.21: I am happy with my math grades (Source: Klelija Zivkovic)

	completely incorrect	incorrect	neutral	correct	completely correct
Mathematics was always easy for me	29,7%	15,5%	30,2%	12,7%	11,8%
Somebody always helped me with my math homework	32,4%	20,0%	23,1%	10,2%	14,2%
I am happy with my mathematics grades	25,6%	9,8%	23,1%	13,9%	27,5%

Table 5.3: Personal experiences/attitudes
(Source: Klelija Zivkovic, Ruth Mateus-Berr)

	completely incorrect	incorrect	neutral	correct	completely correct
Mathematics is essential for all humans	3,2%	6,9%	32,4%	24,4%	33,1%
Mathematics is difficult and hard	8,9%	14,1%	34,0%	18,9%	24,2%
Mathematics improves intelligence	2,6%	3,5%	18,9%	24,3%	50,7%
Mathematics is not important for everyday life	45,4%	16,2%	19,9%	9,9%	8,7%
Mathematics is the most important course in school	15,8%	13,4%	34,1%	23,8%	12,9%
Knowing mathematics opens doors for a future career	9,4%	13,2%	39,0%	21,2%	17,2%
There is not enough Mathematics in school	48,0%	20,5%	21,0%	6,0%	4,5%

Table 5.4: General Beliefs/Attitudes (Source: Klelija Zivkovic)

5.3.1.5 Education

55% of all students surveyed believed that most of their classmates were bored in math classes. 17,8% pupils disagreed, while 27% pupils remained undecided on this question (Figure 5.22). 53% did not consider their math classes boring, just 22,1% claimed the opposite (Figure 5.23). This appears in marked contrast to the question asked before. Why should classmates be bored, when 53% consider their math classes interesting? Nearly 70% believed that there was a more entertaining way to teach math, while only 10,4% were content with the way it was being taught at that time. Almost 20% remained undecided (Figure 5.24). About 50% of pupils thought that math teachers are very good, while 17,8% of found that not all math teachers were good. Most of the pupils, almost 32%, remained undecided (Figure 5.25). Around 36% believe that most math presentations could be improved and do have influence on learning output, while around 40% believe the opposite and 25% remained undecided (Figure 5.26). Almost 70% of the pupils interviewed disagreed with the statement that math was taught to them in an unsatisfactory way and seem to be content, just 12,2% agreed. Around 18% of pupils remained undecided on this question (Figure 5.27). Around 56% of the pupils wished they knew more mathematics. The remaining half is divided into the nearly 20% who didn't wish they knew more, and around 25% who weren't sure (Figure 5.28). Around 74% of pupils appreciated spending time with math, while around 11% felt that math lessons were a waste of time. Around 15% remained undecided (Figure 5.29). Nearly 40% wished they had paid more attention during math classes, while 33,2% were content with their attitude (Figure 5.30).

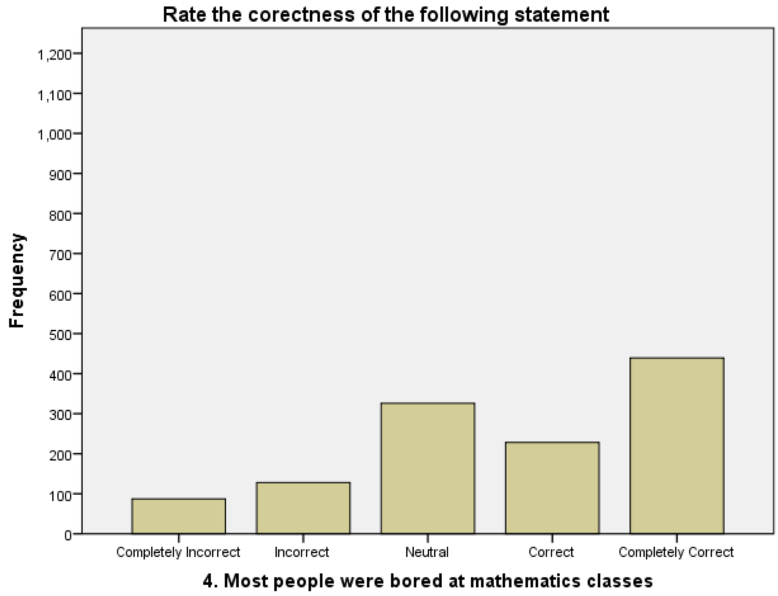

Figure 5.22: Most people were bored (Source: Klelija Zivkovic)

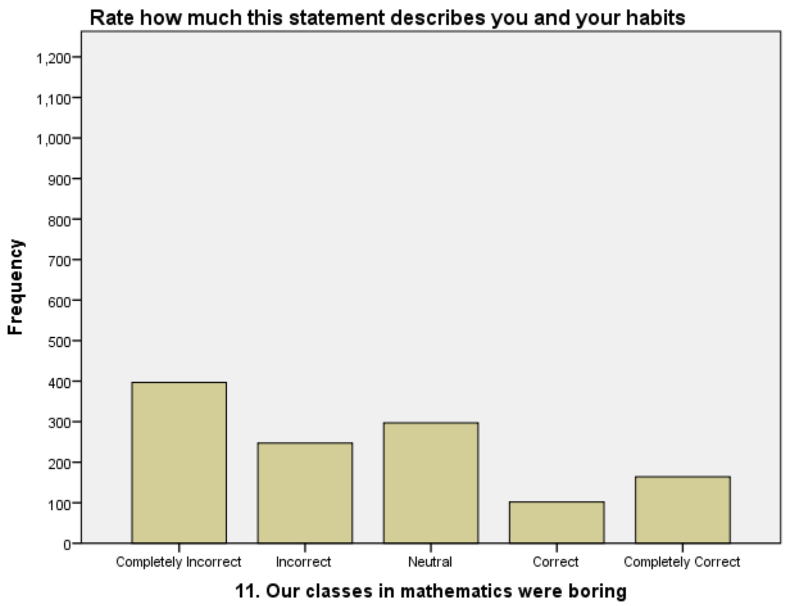

Figure 5.23: Boring math classes (Source: Klelija Zivkovic)

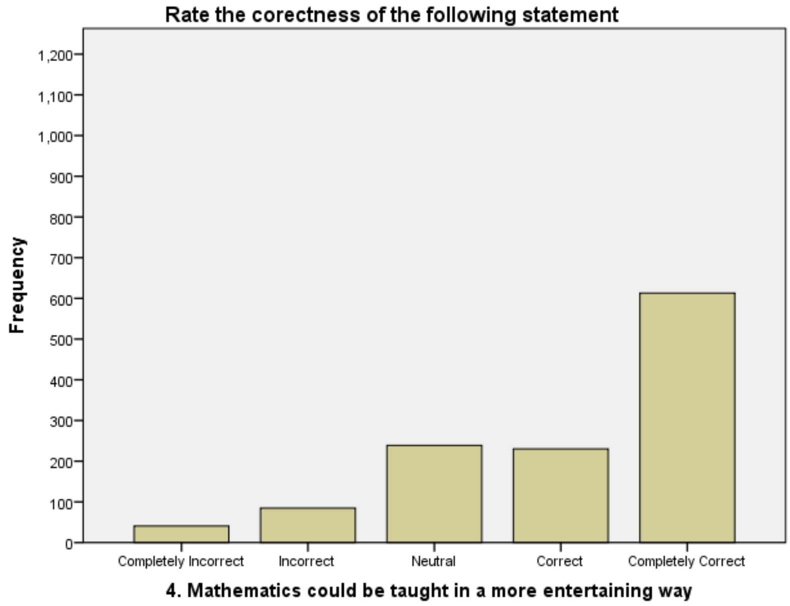

Figure 5.24: Mathematic could be taught in a more entertaining way
(Source: Klelija Zivkovic)

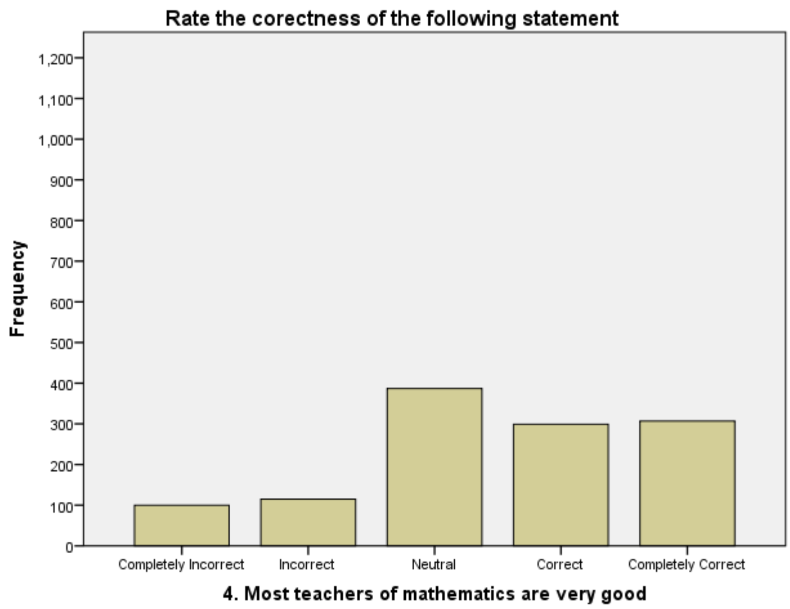

Figure 5.25: Most teachers of Mathematics are very good
(Source: Klelija Zivkovic)

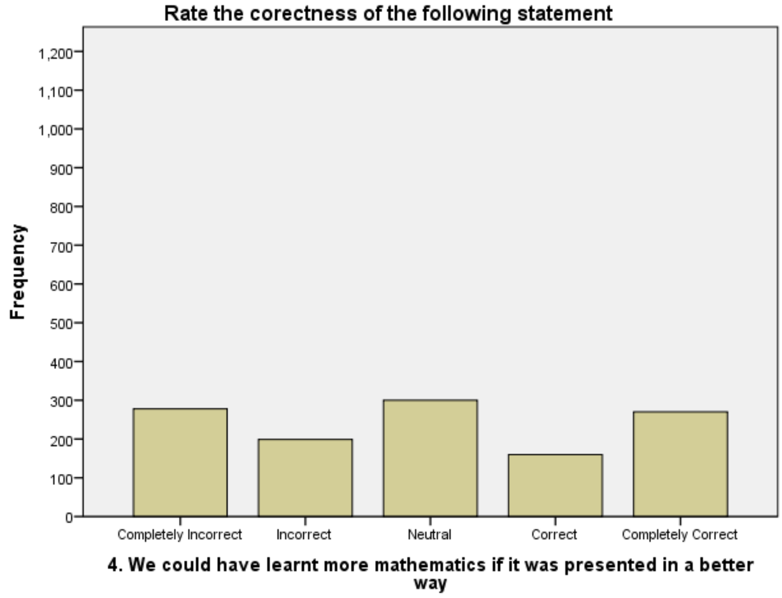

Figure 5.26: Learned more- better presentations (Source: Klelija Zivkovic)

Figure 5.27: Mathematic was taught to me incorrectly
(Source: Klelija Zivkovic)

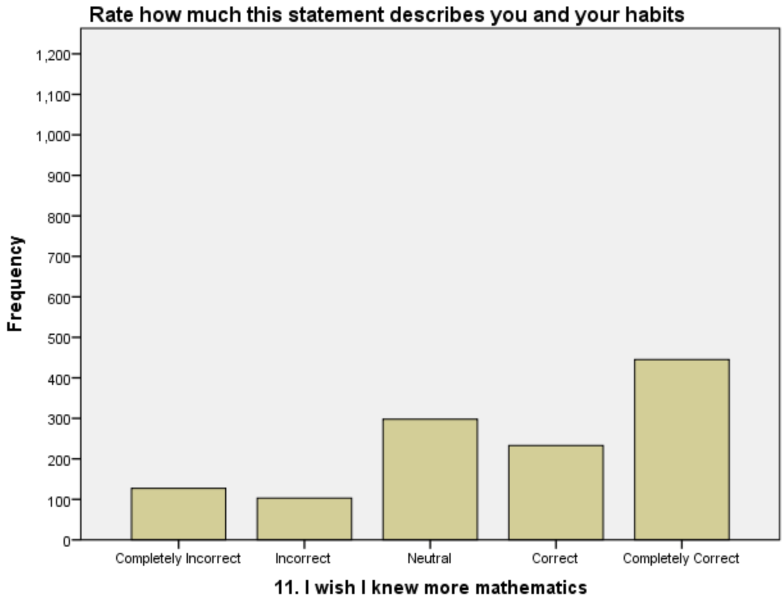

Figure 5.28: I wish I knew more Mathematics (Source: Klelija Zivkovic)

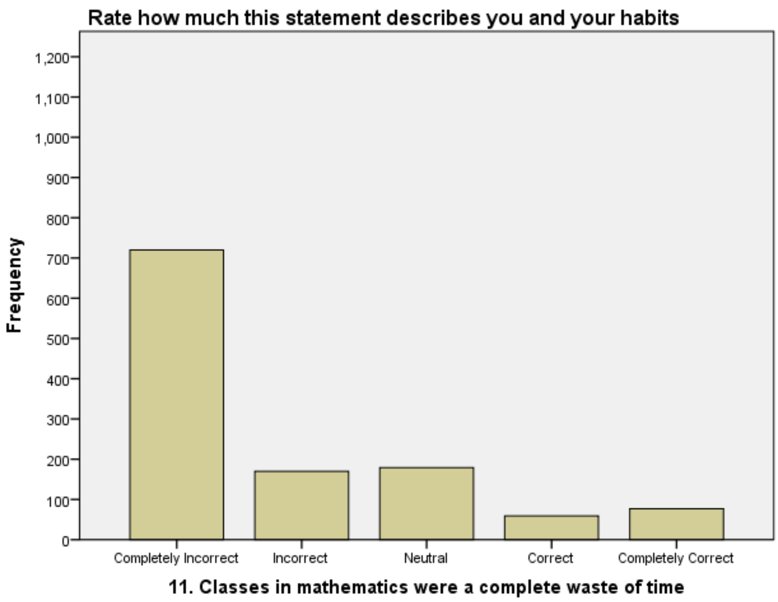

Figure 5.29: Classes in Mathematics- waste of time (Source: Klelija Zivkovic)

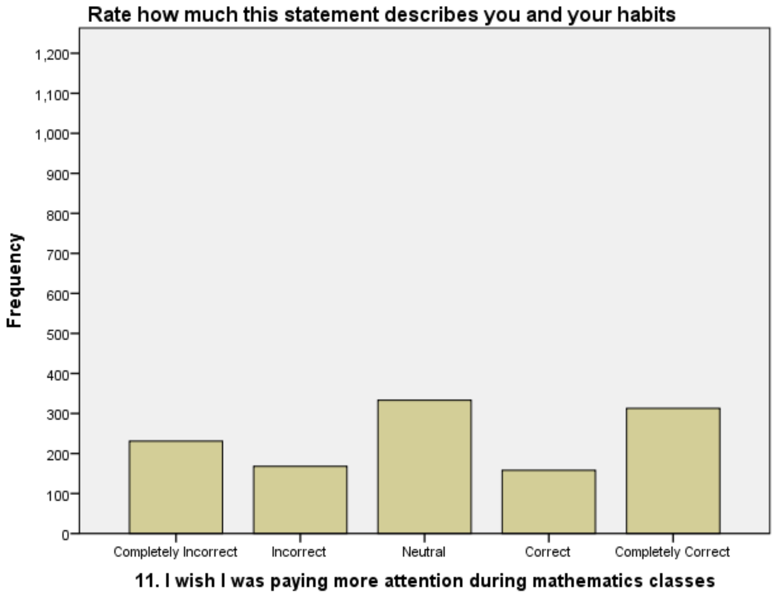

Figure 5.30: I wish I had paid more attention during math classes (Source: Klelija Zivkovic)

More than 80% believed that they were well prepared for the math they had needed in their lives until the day of the survey (Figure 5.31). Although this question about acquired knowledge in mathematics is difficult to answer for pupils still attending school, more than 77% of the pupils believed that they have been learning a lot of mathematics during their education (Figure 5.32).

Most of the surveyed pupils, 68,5% think that the math in schools is enough. In contrast to this, 10,5% agreed with the statement and felt that they need more mathematics in their schools (Figure 5.18).

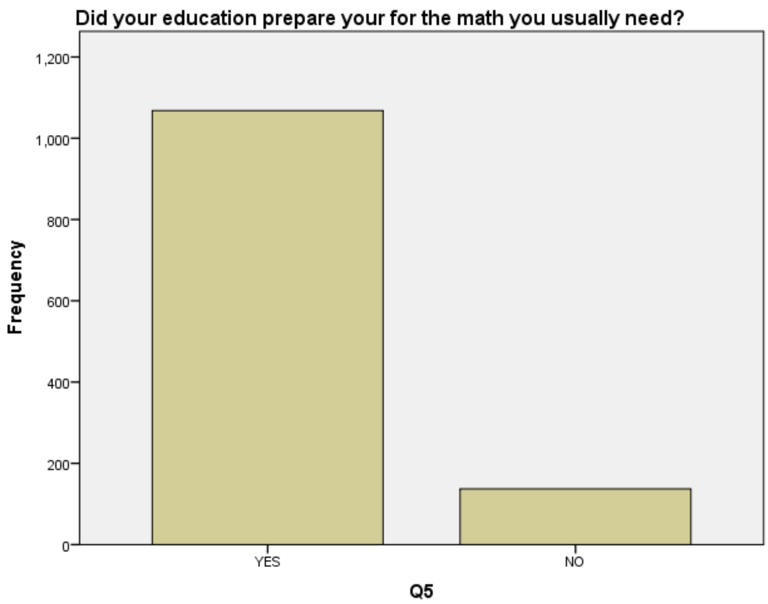

Figure 5.31: Math education prepared well (Source: Klelija Zivkovic)

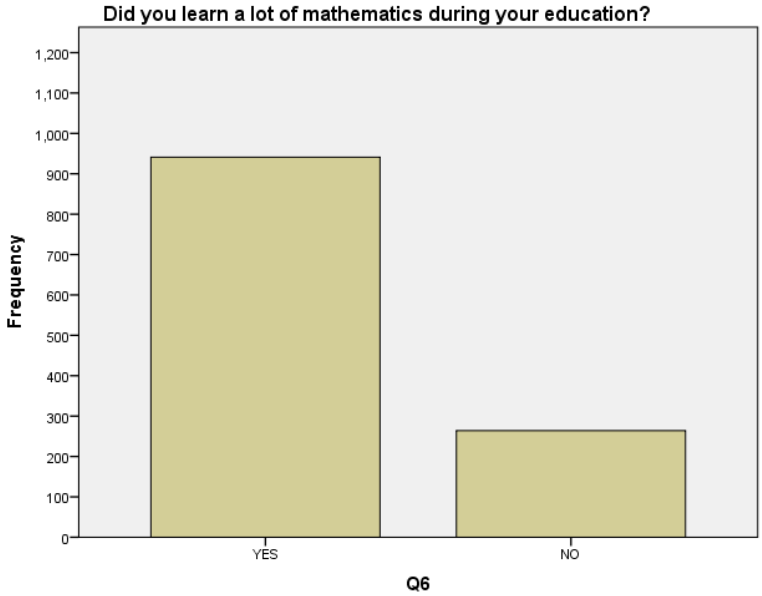

Figure 5.32: Gained knowledge in mathematics (Source: Klelija Zivkovic)

	completely incorrect	incorrect	neutral	correct	completely correct
Most people were bored at mathematics classes	7.2%	10.6%	27.0%	18.9%	36.3%
Mathematics could be taught in a more entertaining way	3.4%	7.0%	19.8%	19.0%	50.7%
There is not enough mathematics in school	48.0%	20.5%	21.0%	6.0%	4.5%
Most teachers of mathematics are very good	8.3%	9.5%	32.0%	24.8%	25.4%
We could have learnt more mathematics if it was presented in a better way	23.0%	16.5%	24.9%	13.3%	22.4%
Mathematics was taught to me in an unsatisfactory way	55.4%	14.3%	18.1%	5.3%	6.9%
I wish I knew more mathematics	10.5%	8.5%	24.7%	19.3%	36.9%
Classes in mathematics were a complete waste of time	59.8%	14.1%	14.9%	4.9%	6.4%
I wish I paid more attention during math classes	19.2%	14.0%	27.7%	13.1%	26.0%

Table 5.5: Education (Source: Klelija Zivkovic)

Summary Me & My Parents

Around 33% of those surveyed think that their parents are satisfied with their math grades, while around 36% felt otherwise (Figure 5.33). Students' satisfaction with grades and their perception of their parents' satisfaction with their performance in math are commensurate (Figure 5.33). Similarly comparable are the answers to the questions "How often do you use math in your everyday life?" and "How often do your parents use math in their everyday lives?" There is just a slight difference between the frequency of students' and parents' use of math. 72,4% of parents are believed to use math "a few times" and "everyday", while just 62,3% of the students stated that they use math that often (Figure 5.34). Around 33% of the students think that their parents are satisfied with their math knowledge, while around 36% felt otherwise (Figure 5.35).

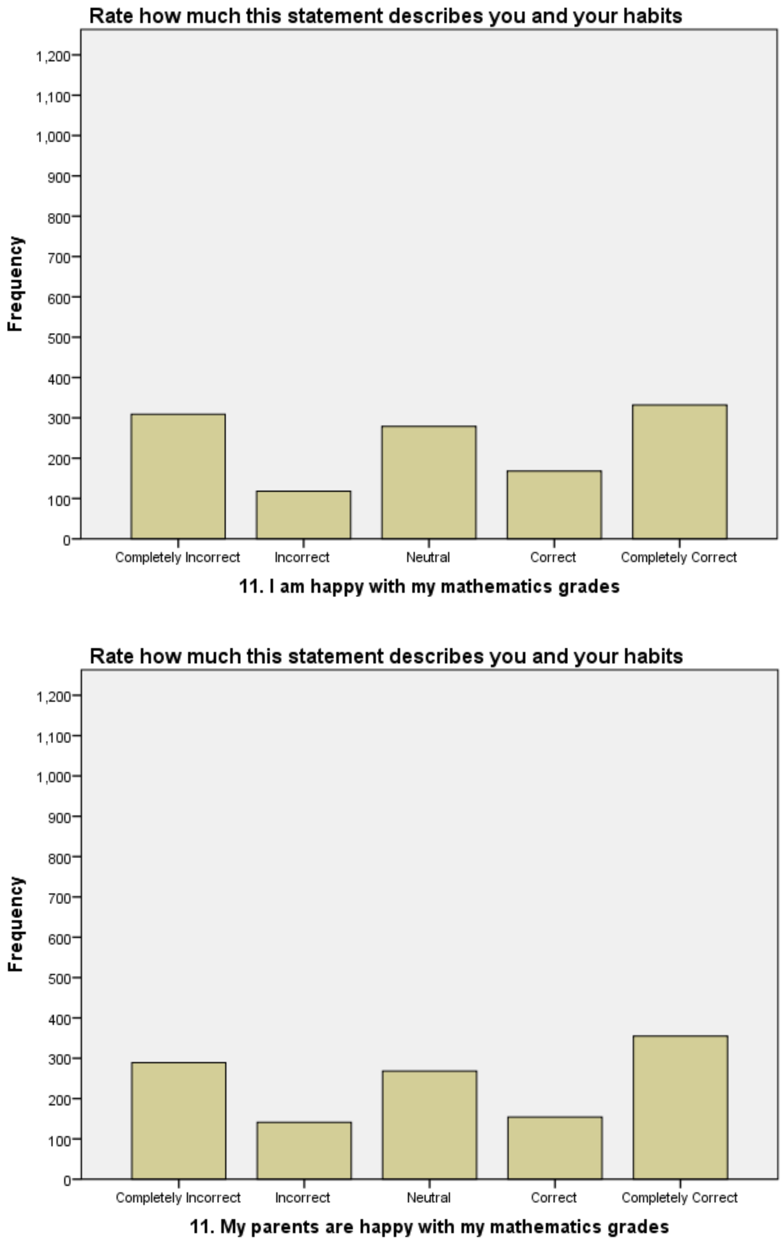

Figure 5.33: Compare happiness with grades students & parents
(Source: Klelija Zivkovic)

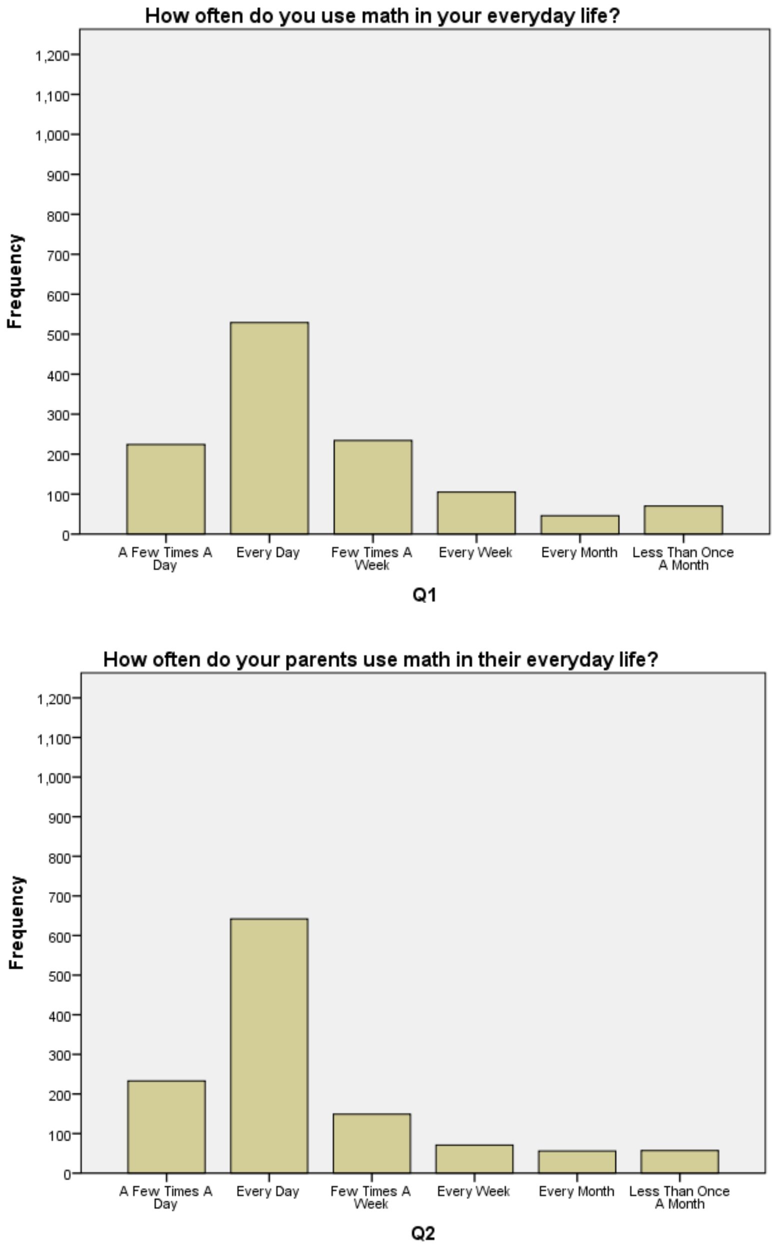

Figure 5.34: Use of math in everyday life students & parents
(Source: Klelija Zivkovic)

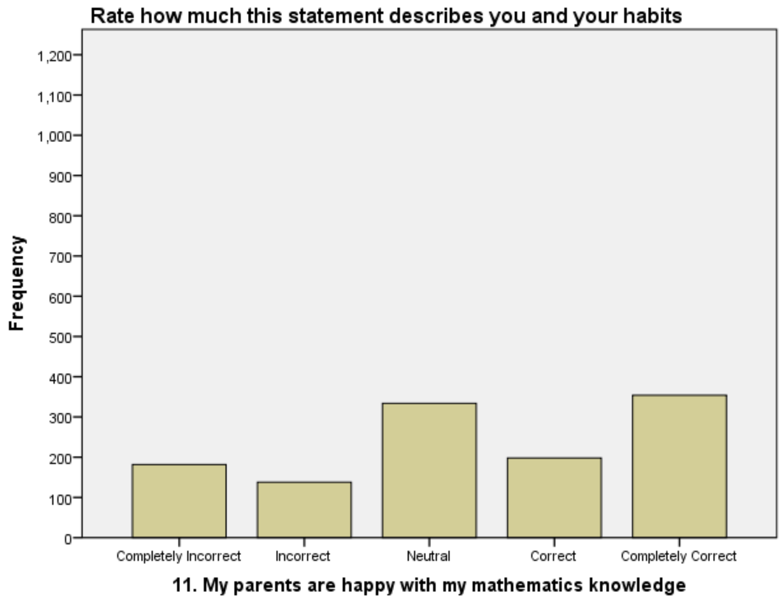

Figure 5.35: Happiness parents knowledge (Source: Klelija Zivkovic)

	completely incorrect	incorrect	neutral	correct	completely correct
I am happy with my mathematics grades	25.6%	9.8%	23.1%	13.9%	27.5%
My parents are happy with my mathematics grades	23.9%	11.7%	22.2%	12.8%	29.4%

Table 5.6: Grades (Source: Klelija Zivkovic)

My parents think it is very important to know mathematics	5,1%	6,7%	24,3%	24,4%	39,5%
My parents think mathematics is important for everyday life	7,8%	9,0%	25,2%	21,5%	36,5%

Table 5.7: Importance of Mathematics (Source: Klelija Zivkovic)

5.3.2 Parental Homes

63% of the mothers of surveyed had completed high school, 31,5% had completed university and 5,5% had completed elementary education (Figure 5.36). 62,4% of the fathers questioned had finished high school, 30,4% had finished university studies and 7,3% had completed elementary education (Figure 5.36). Of the mothers that had third-level qualifications, most were graduates in Law and Economics (44%), followed by Biology and Medicine (21,9%), then Humanities (17%) and a similar number in Science and Math (16,7%) (Figure 5.37). Out of a total of 355 fathers who had been to university, 58,8% had studied Science and Math, 110 Law and

Economics (24,8%); the least represented subjects were Biology and Medicine (11%), and Humanities (5,4%) (Figure 5.37). The fathers provided the higher proportion of graduates in Science and Mathematics. Most of the pupils whose mothers and fathers had finished second-level education believe their parents used math on a daily basis (mothers Figure 5.38, fathers Figure 5.39).

Nonetheless, in each cluster the bar which reaches the highest scale is always that representing the everyday use of math, which shows that from among those surveyed there is a widely-held belief that math is an important tool in everyday life.

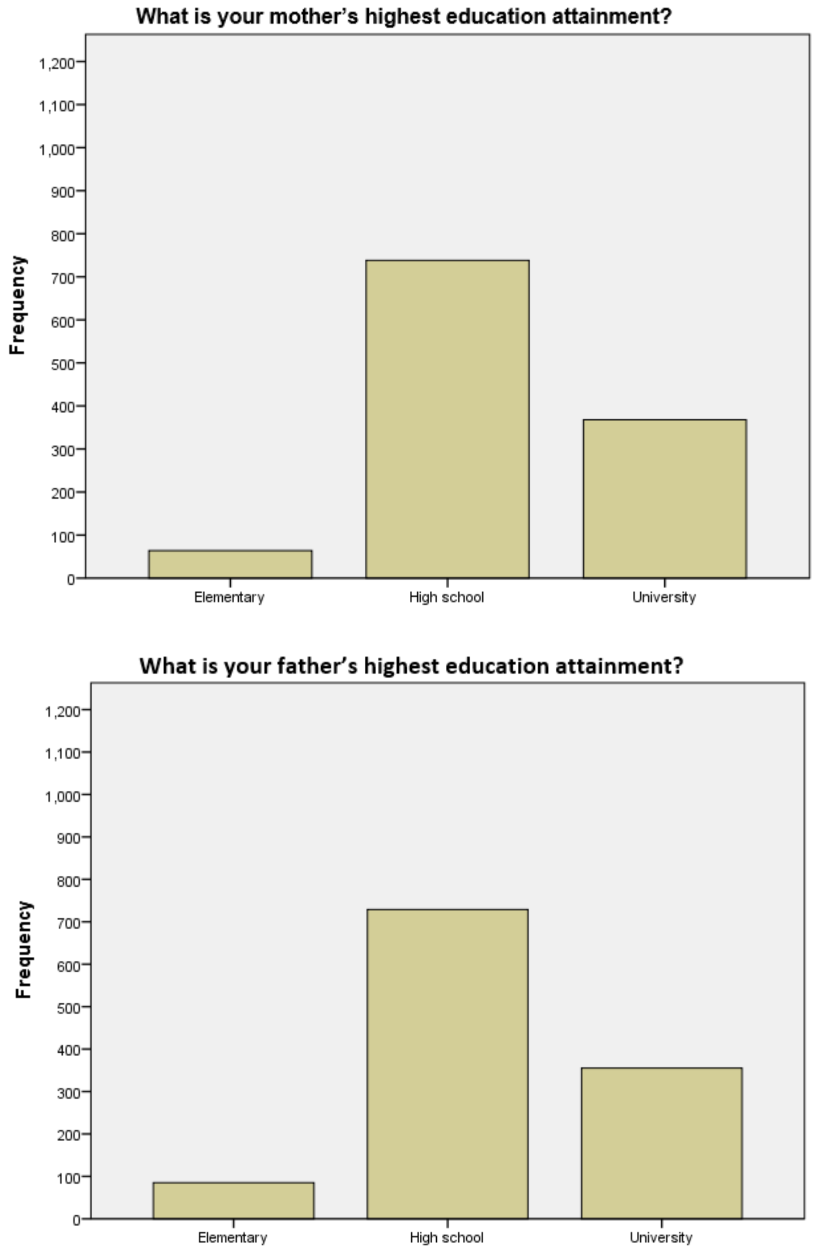

Figure 5.36: Education mother & father (Source: Klelija Zivkovic)

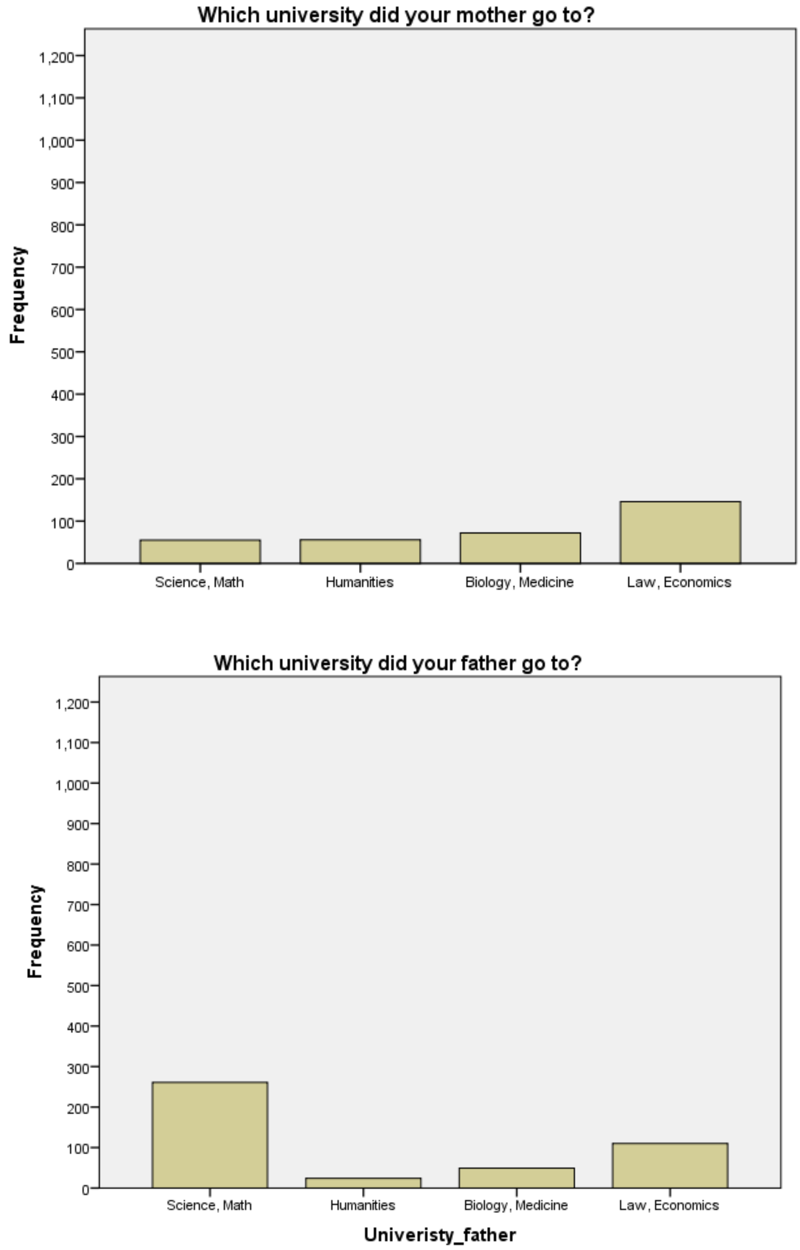

Figure 5.37: Education mother & father (Source: Klelija Zivkovic)

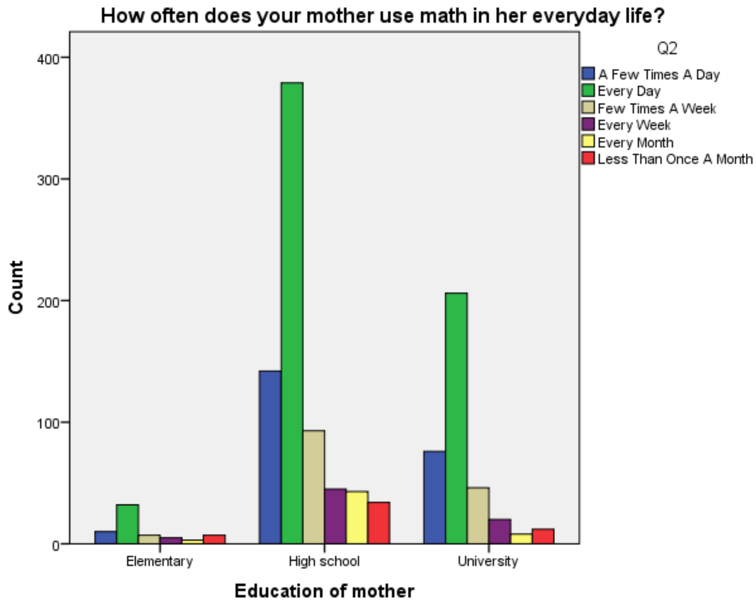

Figure 5.38: Use of math in everyday life/mother (Source: Klelija Zivkovic)

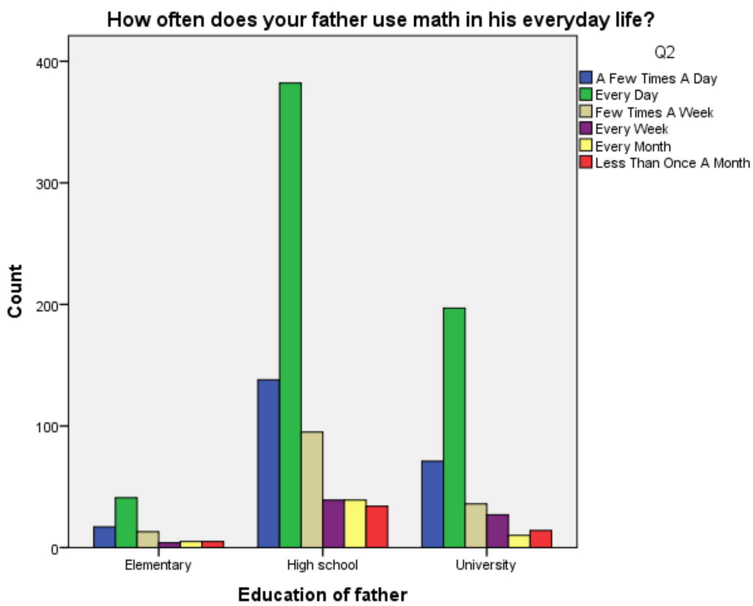

Figure 5.39: Use of math in everyday life/father (Source: Klelija Zivkovic)

	completely incorrect	incorrect	neutral	correct	completely correct
My parents are happy with my mathematics knowledge	15,1%	11,4%	27,7%	16,4%	29,4%
My parents think it is very important to know mathematics	5,1%	6,7%	24,3%	24,4%	39,5%
My parents think mathematics is important for everyday life	7,8%	9,0%	25,2%	21,5%	36,5%
How often do your parents use math in their everyday life?	23,9%	11,7%	22,2%	12,8%	29,4%
I am happy with my mathematics grades	25,6%	9,8%	23,1%	13,9%	27,5%
My parents are happy with my mathematics grades	23,9%	11,7%	22,2%	12,8%	29,4%
How often do you use math in your everyday life?	25,6%	9,8%	23,1%	13,9%	27,5%

Table 5.8: Parental Homes (Source: Klelija Zivkovic)

5.3.3 Teaching

43% of pupils, when surveyed, said that teachers never applied computer-based media in the classroom, 15,1% claimed that it was rarely used. Just 6,1% of pupils said that their teachers always used it (Figure 5.40). 40,1% of pupils asserted that their teachers never used presentations (e.g. PowerPoint) in their classes, 16,2% said rarely, 26,1% answered sometimes, 10,9% often and 6,7% always (Figure 5.41). Almost 35% of pupils surveyed stated that their teachers never used real physical objects and models in their teaching practice, 20,8% stated rarely, 25% sometimes, 11,2% often and only 7,9% claimed their teachers always used real objects and models in school (Figure 5.42). 74% of the pupils responded that they had never used computer games in the classroom. Around 11,8% pupils said that their teachers rarely used computer games and only 3% that their teacher always used computer games (Figure 5.43). More than 27,7% of pupils surveyed said that their teachers never used mathematical stories, anecdotes or historical facts to illustrate teaching points, 16,3% answered rarely, just over 27,7% answered sometimes, almost 14,8% said often, and only 13,4% of pupils answered that their teachers always used stories, anecdotes, or historical facts in the classroom (Figure 5.44). About 47,6% of pupils asserted that their teachers never used individual games and playful activities in their classes, just 17,7% answered rarely, 18,2% answered sometimes, about 9% answered often, and only 7,5% said that their teachers always used individual games and playful activities in the classroom (Figure 5.45). 49,7% of those questioned said that their teachers never used the Internet as a tool in their teaching, 13% answered rarely, 17,5% answered sometimes, 9,1% answered often, and 10,7% said that their teachers always used the Internet in the classroom (Figure 5.46). More than 72,5% of the pupils stated that their teachers never used art, painting and sculpture in their classes, 13,3% answered that they used it rarely, 8,9% answered sometimes, 3% answered often, and only 2,5% answered that their teachers always used art, painting and sculpture in the classroom (Figure 5.47). More than 77,7% of pupils stated that their teachers never used art, music and dance while teaching, 8,7%

said rarely, 5,6% said sometimes, 3,3% said often, and 4,7% said that their teachers always used art, music and dance in the classroom (Figure 5.48). 74,6% of surveyed pupils asserted that their teachers never showed math-related art movies in their lessons, 1,7% said that they rarely utilized movies, 9% said sometimes, 3,8% said often, and only 21 students said that their teachers always played movies during their math lessons (Figure 5.49). More than 72,2% of pupils answered that their teachers never used role-play games in their classes, 10,1% answered rarely, 11,1% answered sometimes, 4,1% answered often and 2,5% answered that they always played role-play-type games in the classroom (Figure 5.50). More than 64,2% of pupils stated that their teachers never took them to visit art or science museums as a part of their math Curriculum, 13,5% stated rarely, 13,2% stated sometimes, 5,9% stated often and 3,2% stated that their teachers always arranged visits to science and art museums (Figure 5.51). More than 75,5% of those surveyed answered that their teachers never played outdoor games with them, 10,3% answered rarely, 8,3% answered sometimes, 3,4% answered often and 2,6% claimed that their teachers always played outdoor games with them (Figure 5.52). More then 28,4% of pupils answered that their teachers never encouraged group work or introduced playful activities, 13,9% answered rarely, 23,5% answered sometimes, 16,4% answered often and 17,7% asserted that their teachers always encouraged group work or introduced playful activities in the classroom (Figure 5.53).

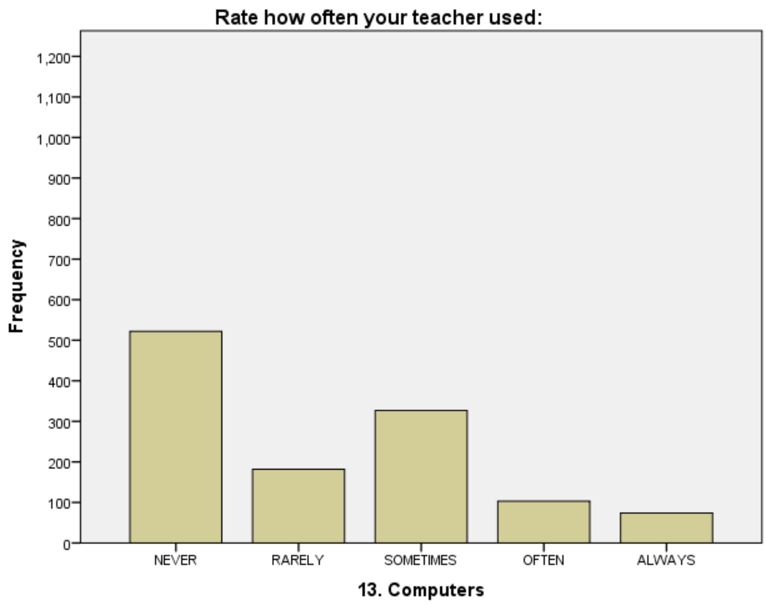

Figure 5.40: Use of Computer (Source: Klelija Zivkovic)

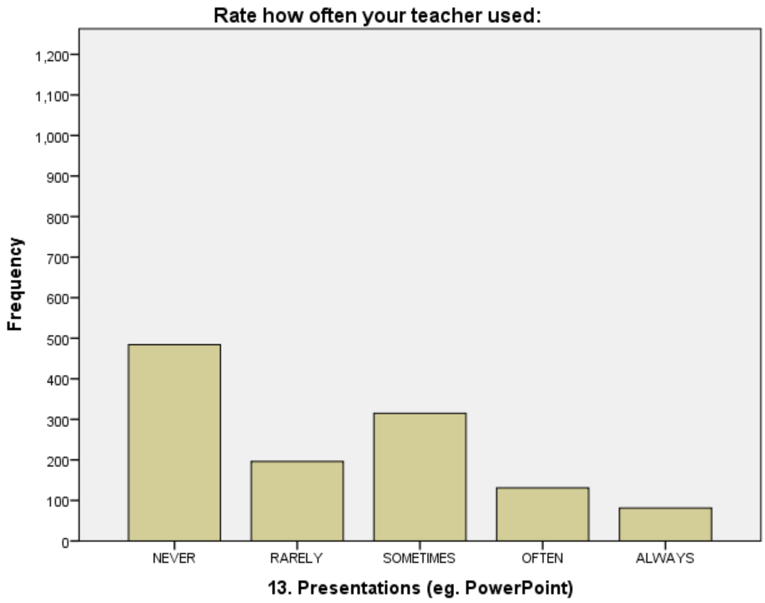

Figure 5.41: Use of presentation software (Source: Klelija Zivkovic)

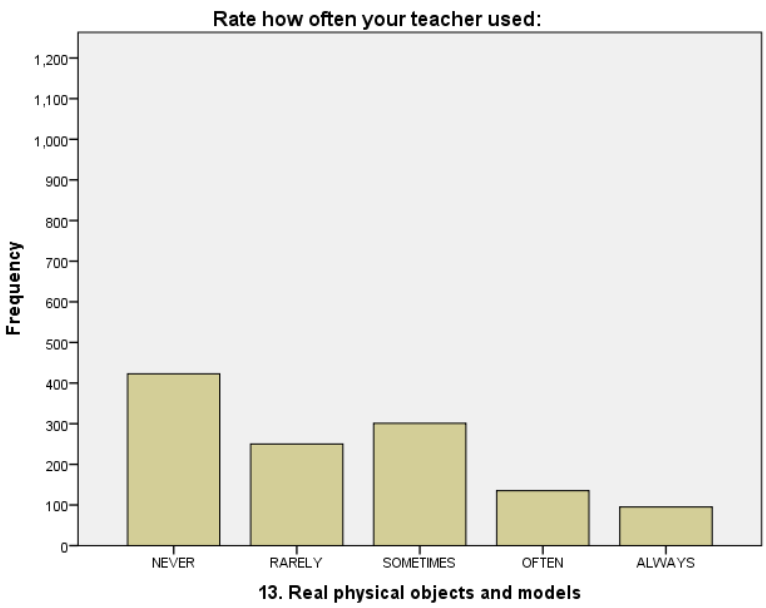

Figure 5.42: Use of real physical objects and models (Source: Klelija Zivkovic)

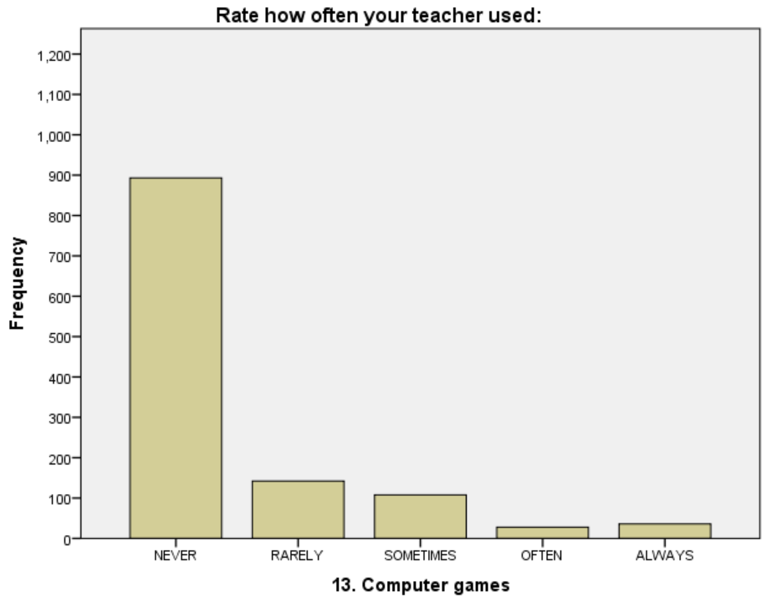

Figure 5.43: Use of computer games (Source: Klelija Zivkovic)

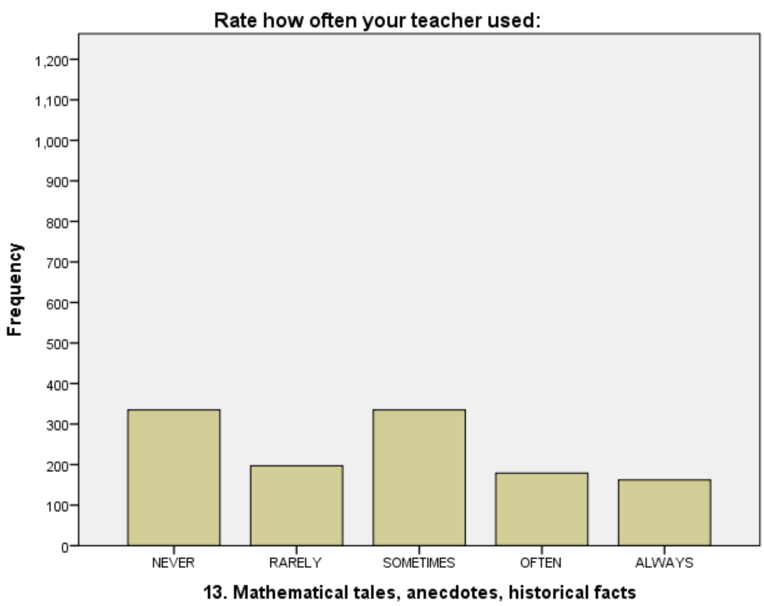

Figure 5.44: Use of mathematical tales, anecdotes, historical facts (Source: Klelija Zivkovic)

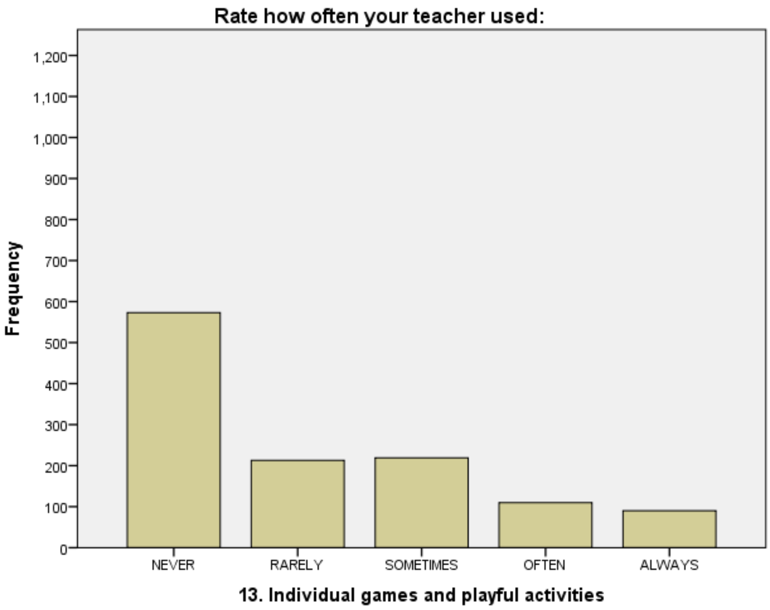

Figure 5.45: Use of individual games and playful activities (Source: Klelija Zivkovic)

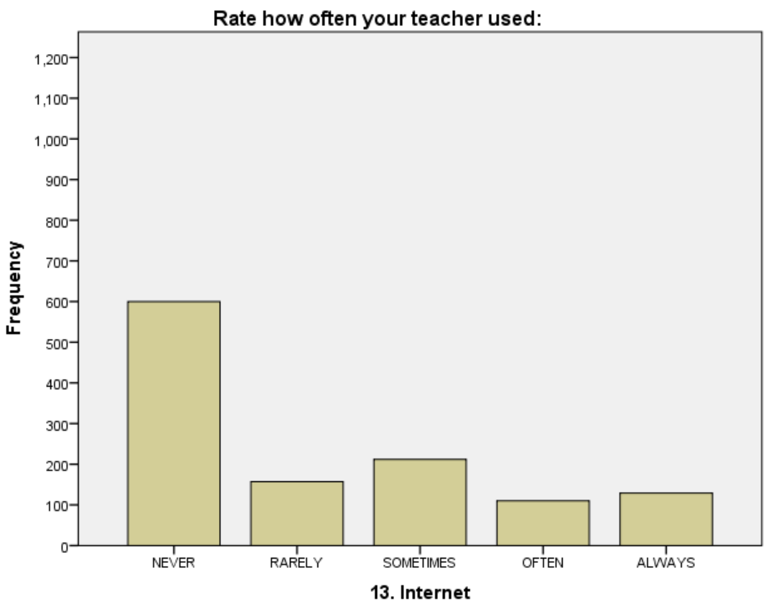

Figure 5.46: Use of Internet (Source: Klelija Zivkovic)

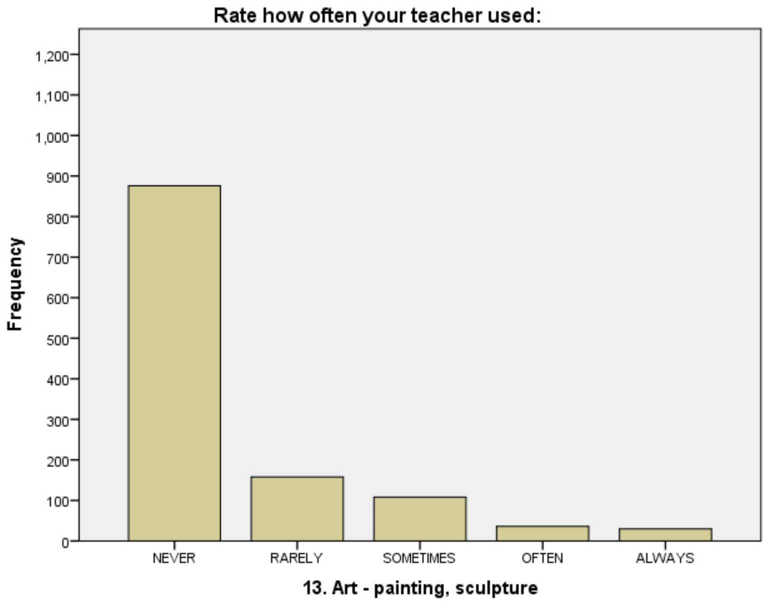

Figure 5.47: Use of art, painting and sculpture (Source: Klelija Zivkovic)

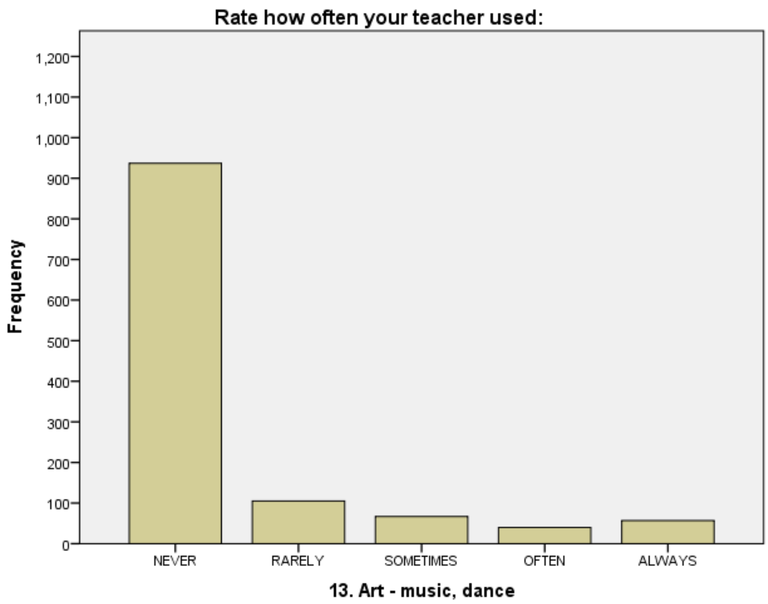

Figure 5.48: Art, music and dance (Source: Klelija Zivkovic)

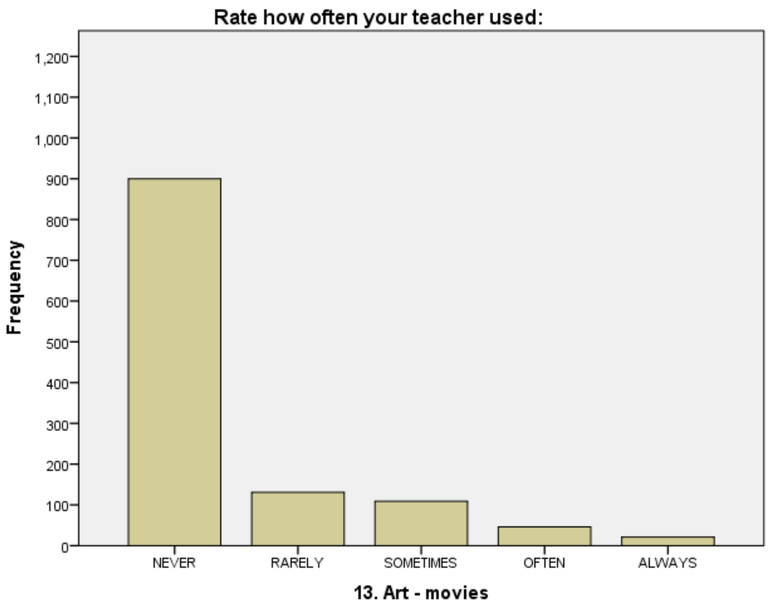

Figure 5.49: Use of art – movies (Source: Klelija Zivkovic)

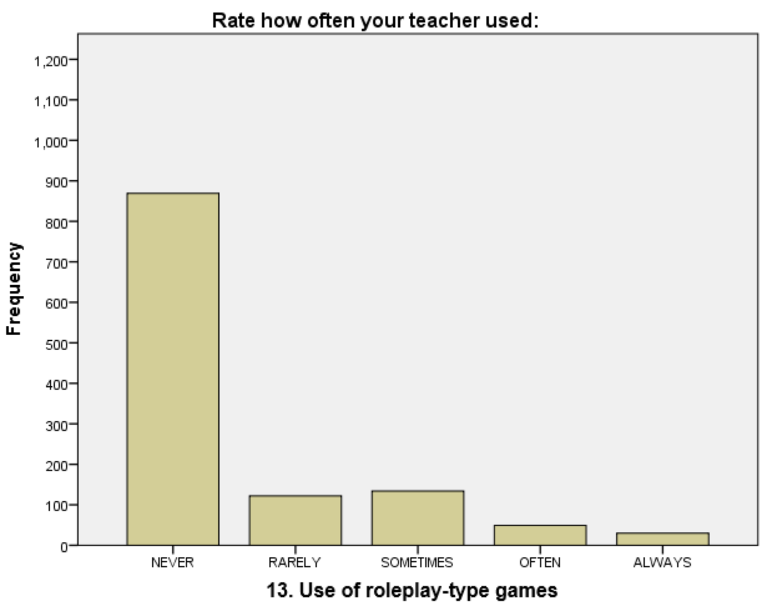

Figure 5.50: Use of situation games (Source: Klelija Zivkovic)

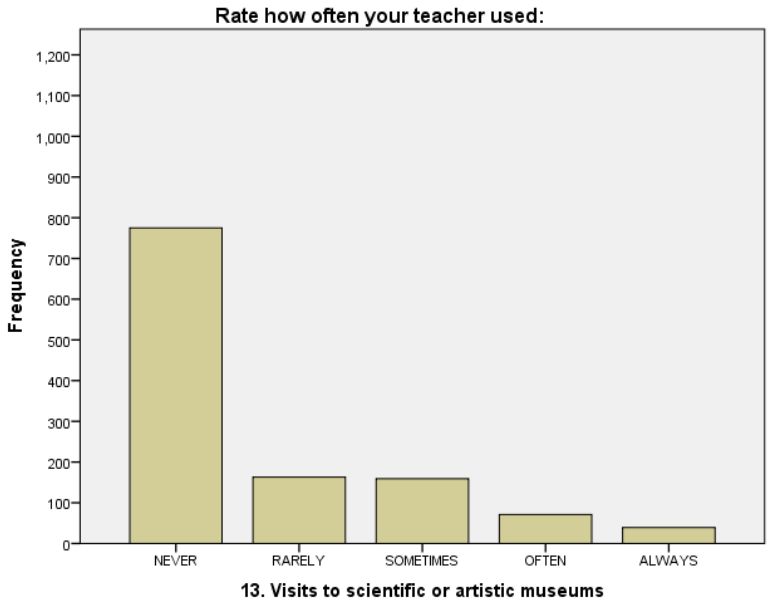

Figure 5.51: Visits to science and art museums (Source: Klelija Zivkovic)

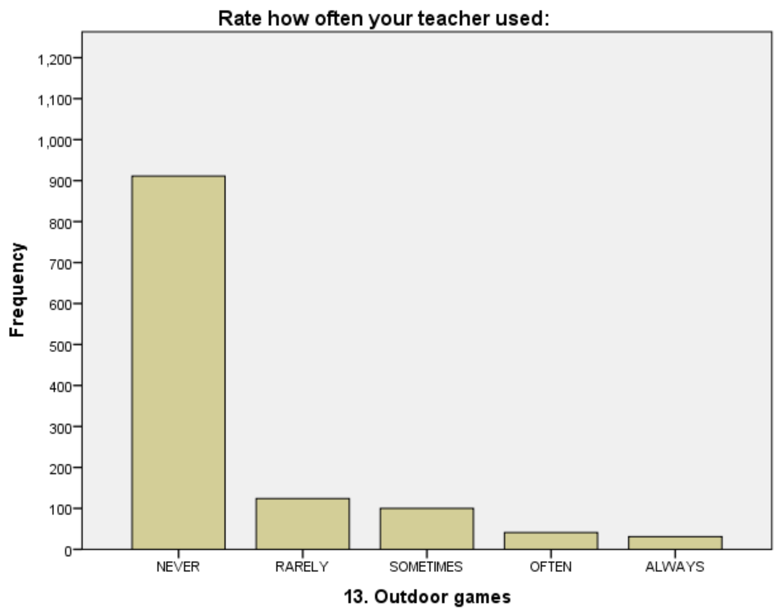

Figure 5.52: Use of outdoor games (Source: Klelija Zivkovic)

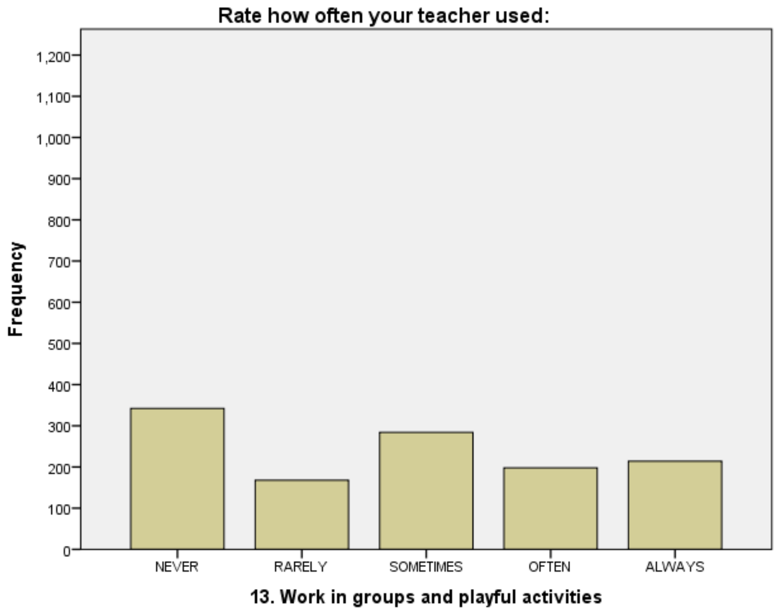

Figure 5.53: Work in groups and playful activities (Source: Klelija Zivkovic)

	never	rarely	sometimes	often	always
Teacher used computers	43,2%	15,1%	27,1%	8,5%	6,1%
Teacher used presentations (e.g. PowerPoint)	40,1%	16,2%	26,1%	10,9%	6,7%
Teacher used real physical objects and models	35,1%	20,8%	25,0%	11,2%	7,9%
Teacher used computer games	74,0%	11,8%	8,9%	2,3%	3,0%
Teacher told mathematical story tales, anecdotes, historical facts	27,7%	16,3%	27,7%	14,8%	13,4%
Teacher used individual games and playful activities	47,6%	17,7%	18,2%	9,1%	7,5%
Teacher used internet	49,7%	13,0%	17,5%	9,1%	10,7%
Teacher used art - painting, sculpture	72,5%	13,1%	8,9%	3,0%	2,5%
Teacher used art - music, dance	77,7%	8,7%	5,6%	3,3%	4,7%
Teacher used art- movies	74,6%	10,9%	9,0%	3,8%	1,7%
Teacher used art- situation games	72,2%	10,1%	11,1%	4,1%	2,5%
Teachers visited art & science museums	64,2%	13,5%	13,2%	5,9%	3,2%
Teachers used outdoor games	75,50%	10,30%	8,30%	3,40%	2,60%
Teachers facilitated group-work and playful activities	28,40%	13,90%	23,50%	16,40%	17,70%

Table 5.9: Teaching Klelija Zivkovic, Ruth Mateus-Berr

Cross Tabulations

These graphs examine the students' self-confidence (SCM) in math and how well prepared they felt for this discipline. It demonstrates the relation between knowing math or being confident in math knowledge and the teaching strategies used by teachers. One of the most obvious patterns is that pupils do feel that their education provided them with the math education they needed for life outside the classroom, even though their teachers did not utilize visual or fun activities often (Figure 5.58–5.72). Unlike the elementary school pupils, the attitude of the high school students towards math peaks at the age of 17, and starts changing as they get older, and have perhaps already settled on a future profession. As the students age, they affirm their belief that math is essential, as well as being the most important course in school (Figure 5.54–5.57). Most of the participants from elementary school and high school were rarely or never exposed to visual, kinesthetic or IT activities during their math classes (Figure 5.58–5.72).

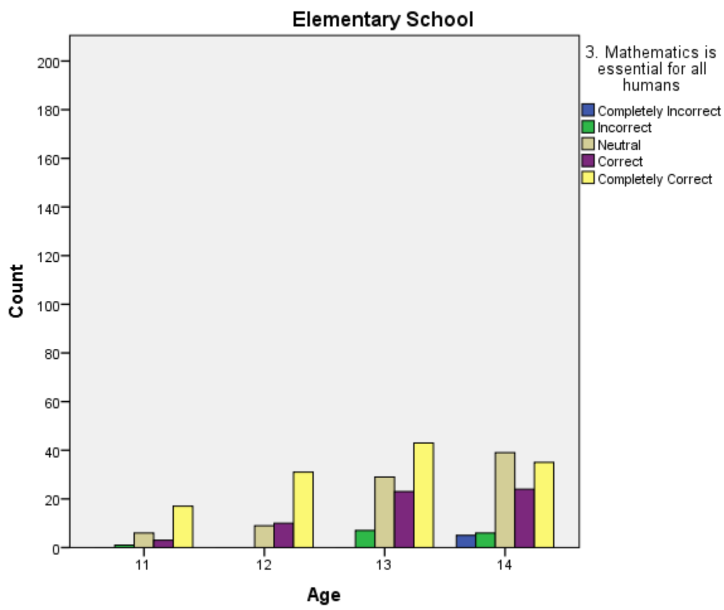

Figure 5.54: Beliefs: Mathematics is essential to all humans/elementary school (Source: Klelija Zivkovic)

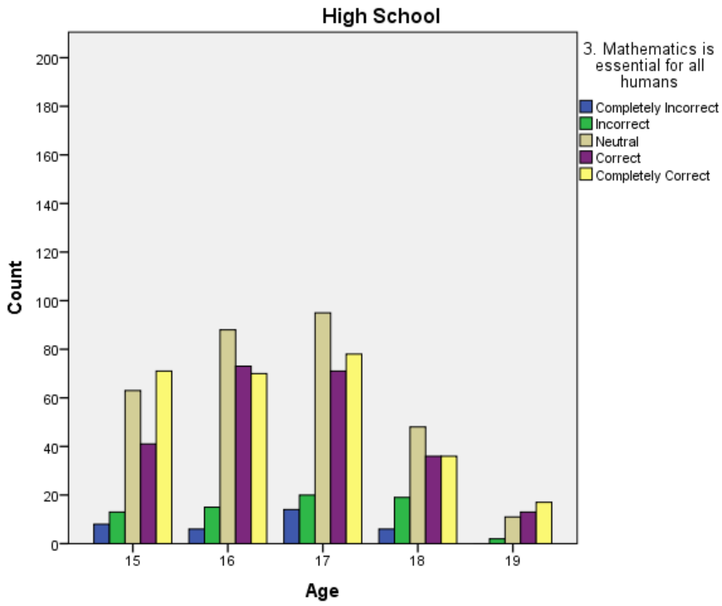

Figure 5.55: Beliefs: Mathematics is essential to all humans/high school (Source: Klelija Zivkovic)

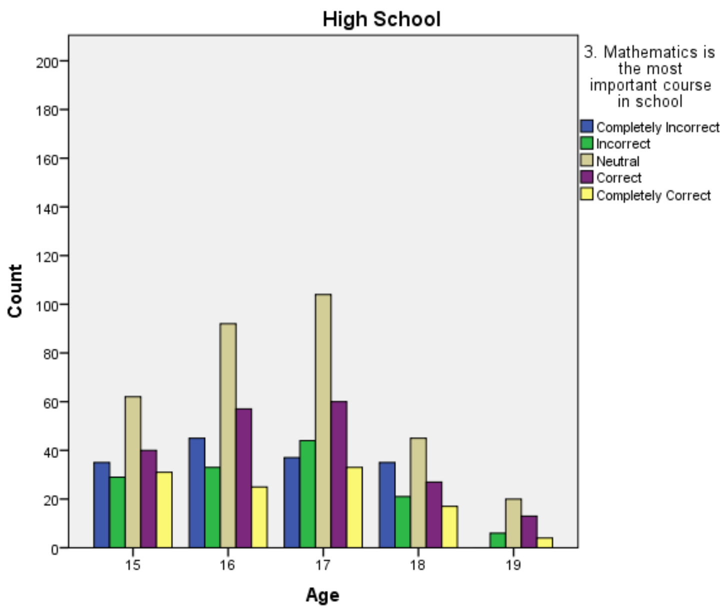

Figure 5.56: Beliefs: Mathematic is the Most Important Course in School/Elementary school (Source: Klelija Zivkovic)

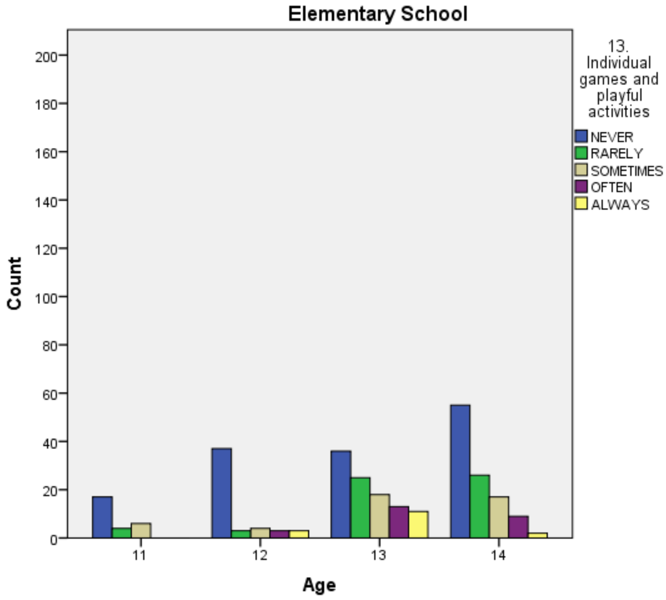

Figure 5.57: Beliefs: Mathematic is the Most Important Course in School/high school (Source: Klelija Zivkovic)

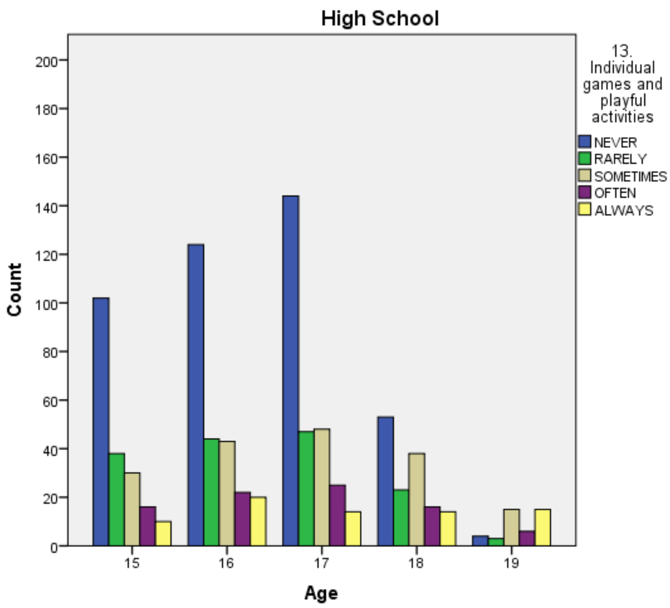

Figure 5.58: Application of Individual Games and Playful Activities/Elementary School (Source: Klelija Zivkovic)

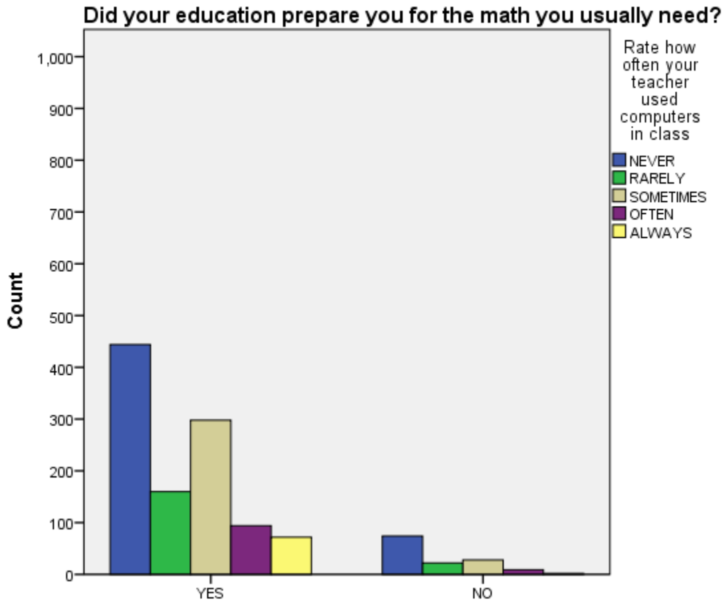

Figure 5.59: Beliefs: Application of Individual Games and Playful Activities/high school (Source: Klelija Zivkovic)

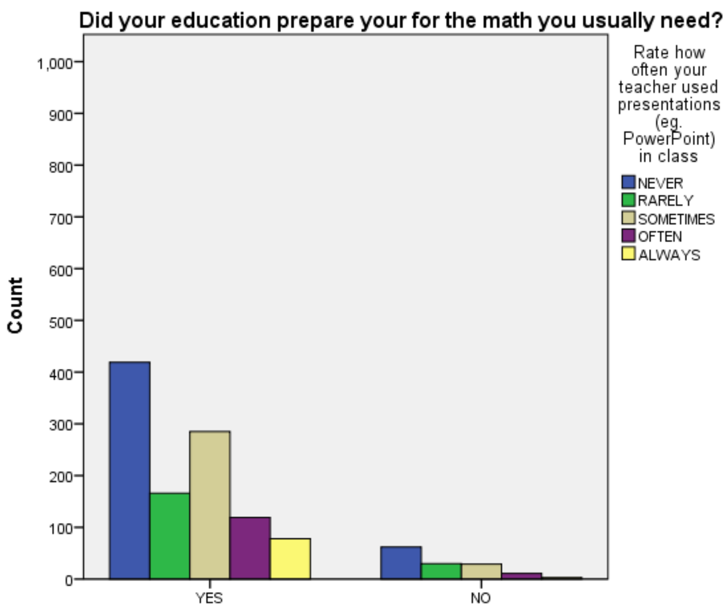

Figure 5.60: Confidence in math knowledge in relation to the use of computers in class (Source: Klelija Zivkovic)

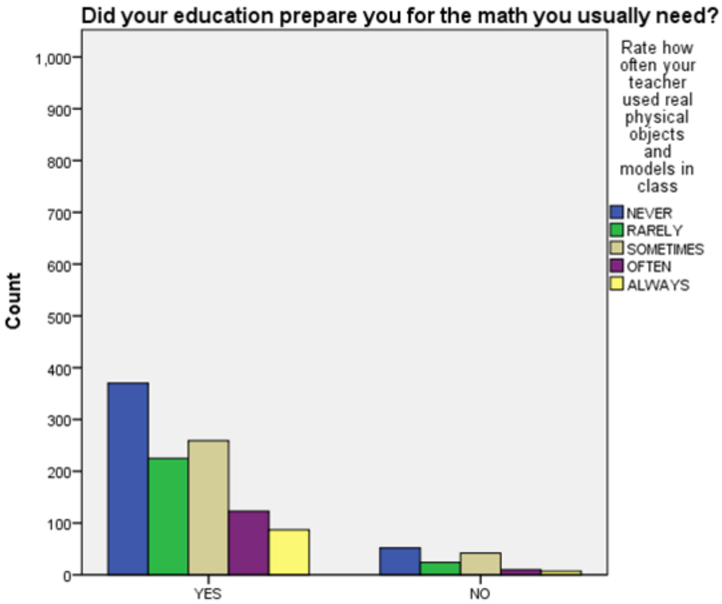

Figure 5.61: Confidence in math knowledge in relation to the use of real physical objects and models in class (Source: Klelija Zivkovic)

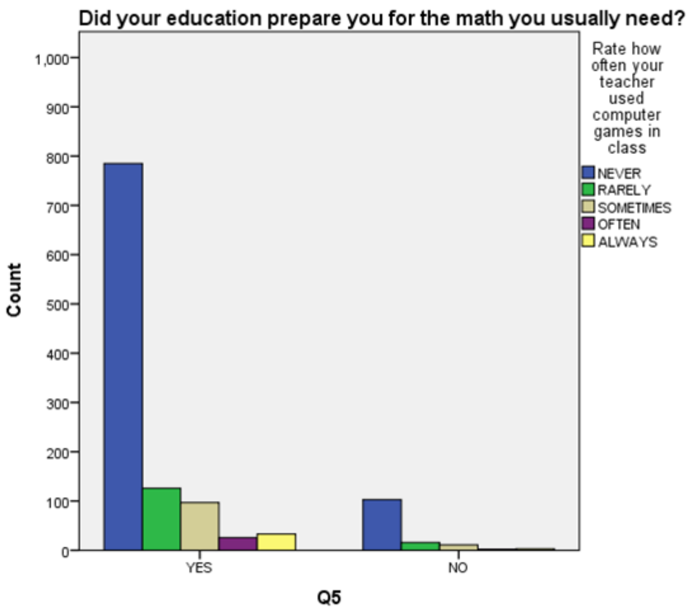

Figure 5.62: Confidence in math knowledge in relation to the use of computer games in class (Source: Klelija Zivkovic)

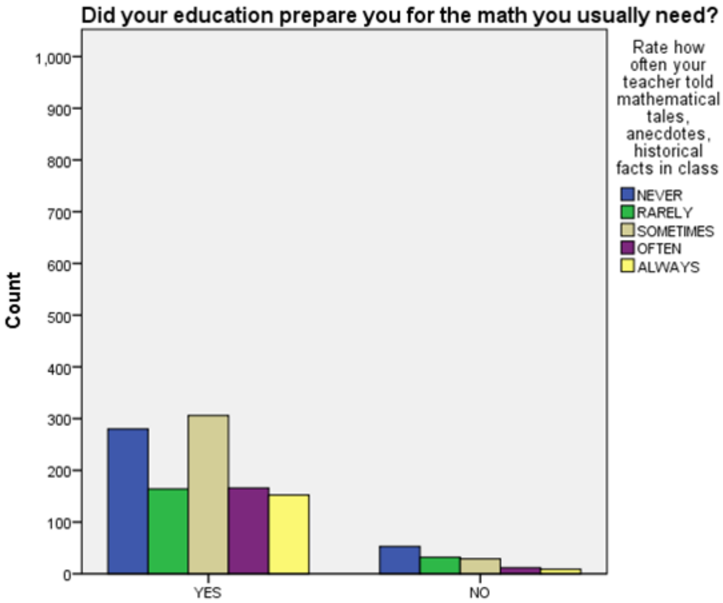

Figure 5.63: Confidence in math knowledge in relation to the Use of mathematical stories, anecdotes, historical facts in class (Source: Klelija Zivkovic)

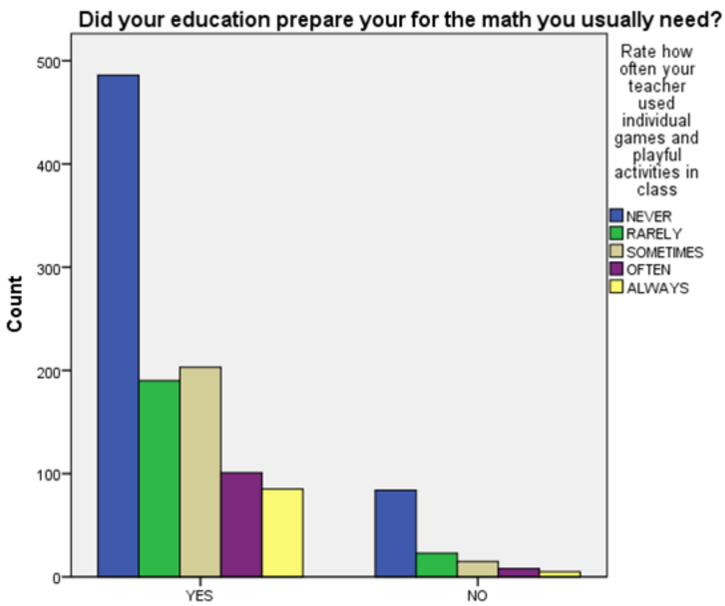

Figure 5.64: Confidence in math knowledge in relation to the use of Individual games and playful activities in class (Source: Klelija Zivkovic)

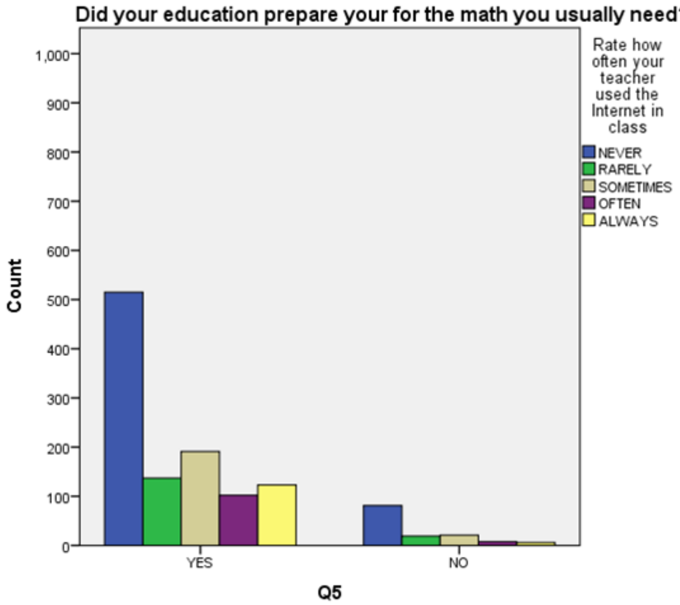

Figure 5.65: Confidence in math knowledge in relation to the use of the Internet in class (Source: Klelija Zivkovic)

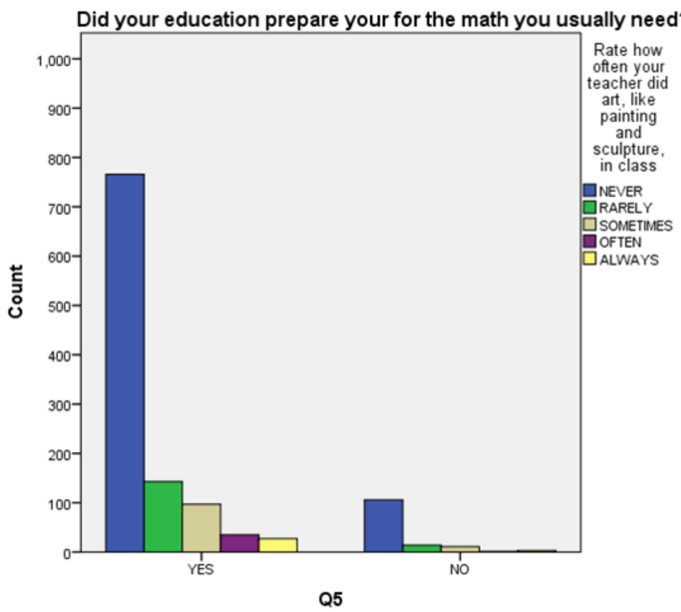

Figure 5.66: Confidence in math knowledge in relation to the use of Art: painting, sculpture in class (Source: Klelija Zivkovic)

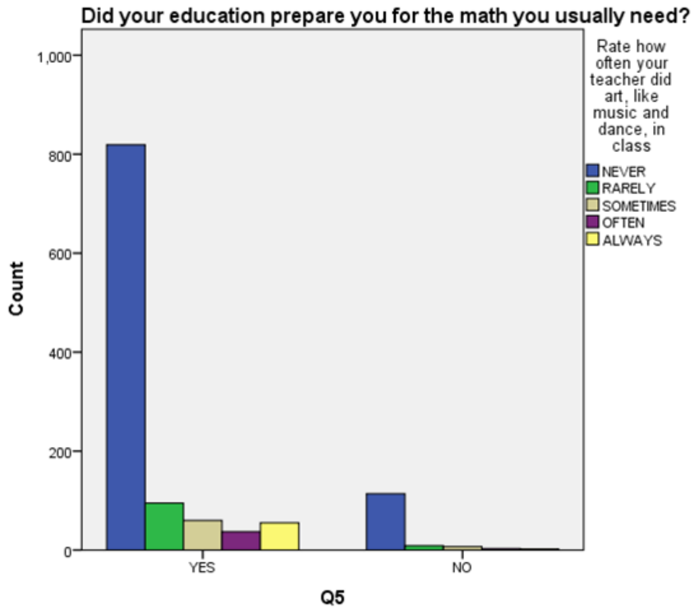

Figure 5.67: Confidence in math knowledge in relation to the use of Art, music & dance in class (Source: Klelija Zivkovic)

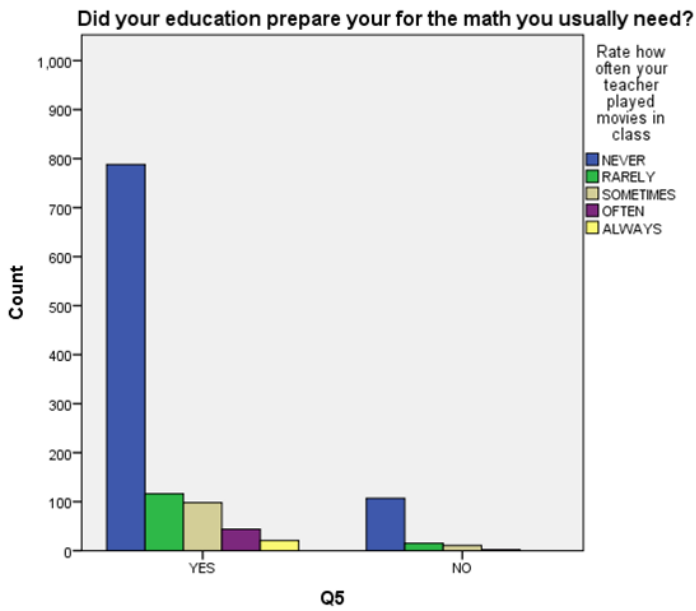

Figure 5.68: Confidence in math knowledge in relation to the use of playing movies in class (Source: Klelija Zivkovic)

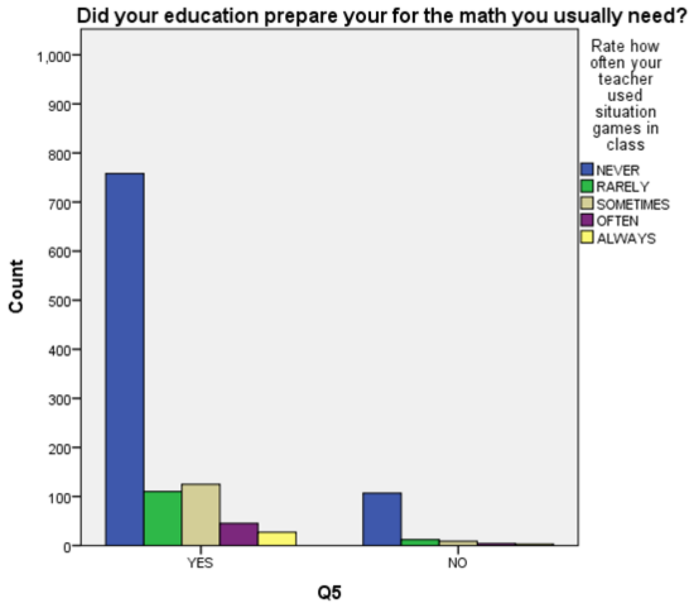

Figure 5.69: Confidence in math knowledge in relation to the use of role-play games in class (Source: Klelija Zivkovic)

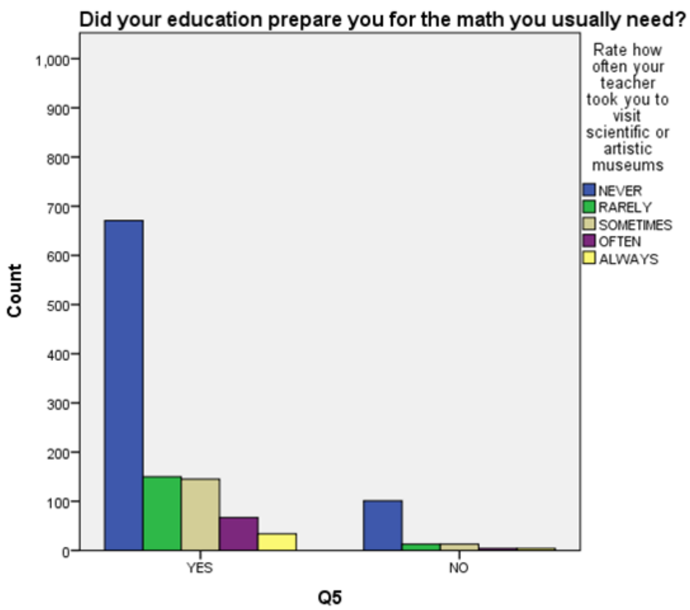

Figure 5.70: Confidence in math knowledge in relation to visits to art and science museums (Source: Klelija Zivkovic)

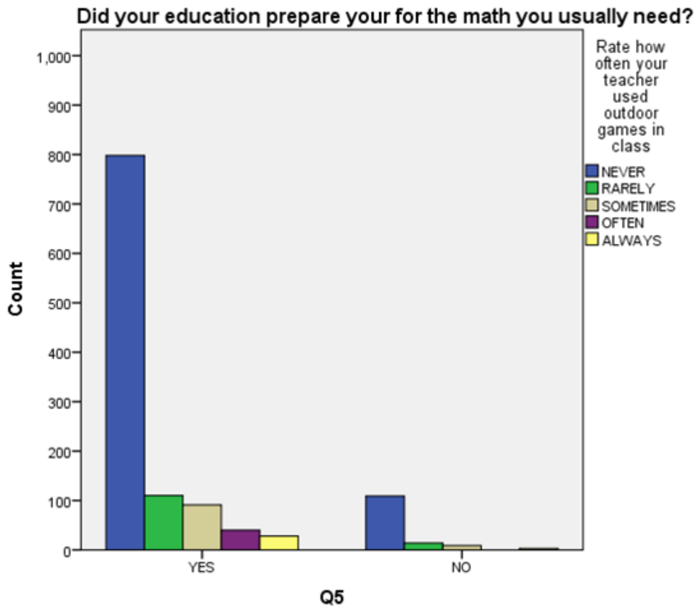

Figure 5.71: Confidence in math knowledge in relation to the use of outdoor games in class (Source: Klelija Zivkovic)

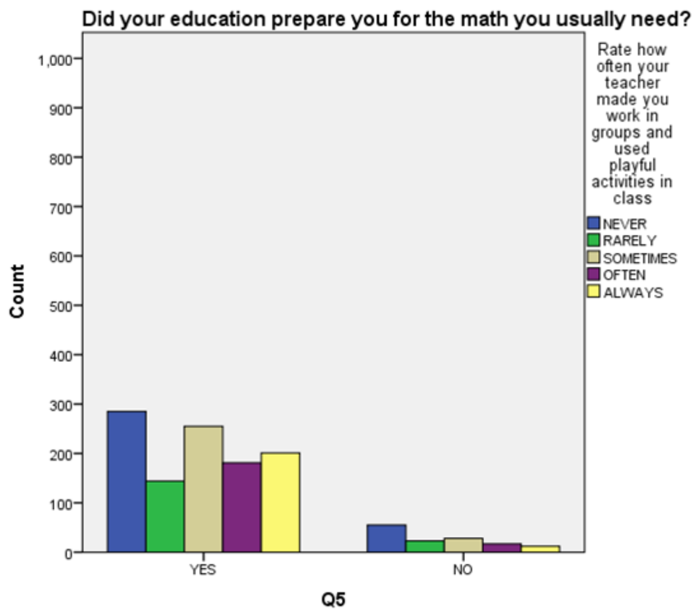

Figure 5.72: Confidence in math knowledge in relation to the use of Group work, playful activities in class (Source: Klelija Zivkovic)

5.3.4 Teachers

Evaluation of Summer School Eger 2014

Lilijana Radovic
Method: Qualitative Interview
Participants: 20

In order to evaluate the Summer School in Eger about twenty Serbian teachers provided feedback to Lilijana Radovic outlining their positive and negative experiences on the course. Among the former were the workshops and the family day, there were, of course, some less favorable comments and participants were encouraged to give suggestions, where possible these were integrated by the organizational staff of VISMATH into the Summer School in Belgrade.

In general, the opinion of the teachers is that the role of a teacher of mathematics is to lead a young child through the process of learning, and that the modern teacher should be able to connect mathematics with other scientific disciplines and art and to introduce young people to mathematics through engaging workshops. In this sense, the Summer School has been very valuable because it has opened up new opportunities and introduced new ideas, significantly expanding horizons in the professional sense. It helped teachers to realize that by linking mathematic with design, astronomy, architecture, visual arts, etc. they can make mathematics more intelligible and accessible, even to those artistic souls among students, as well as make their classes more interesting and relevant to the world outside the classroom. The most important part of the Summer School was communication with the other participants because different approaches to problems led to an exchange of ideas, which certainly contributed to more creative solutions. Workshops that provided concrete examples and possibilities of applying them in teaching received the most favorable feedback from participants. Teachers were especially satisfied with "The Teachers Day", where teachers and students had the opportunity to present their specific experiences of teaching and presented examples of stimulating classes. Some participants of the Summer School had the opportunity to present their ideas through workshops and related activities on family day, to which the inhabitants of Eger, children and adults, were invited; neither the language barrier nor a lukewarm attitude toward mathematics seemed an issue. Many participants left believing that this kind of presentation of mathematics should be practiced in their schools in order to popularize math. There was also a general consensus that more, well-organised events of this type advocating science and mathematics should be promoted.

Unfavorable comments on the Summer School in Eger focused on a number of issues: the schedule was said by some to be too ambitious and left little time in between events to gather thoughts and prepare for the next lecture. Some felt that there should have been more roundtable discussions, workshops and lectures, and that teachers should have been required to design a math class on a subject that they had studied that day. They also suggested that rather than confining lectures to the relationship between mathematics and real-life to geometry, other sciences and fields should be included like medicine, industry, economy etc. The inclusion of comparative reviews of national school systems (Hungary, Finland, Austria) was something that was also highlighted in the feedback. Another suggestion was that the next Summer School should incorporate examples of good practice, illustrating how teachers from the previous meeting brought visual, haptic or IT approaches to their classes. Teachers participating in the Summer School in Eger founded a Facebook group where they are able to exchange projects and ideas:

https://www.facebook.com/groups/394019847368919/

After the Summer School in Eger, teachers took part in qualitative interview research, supplemented by the many comments submitted by participants. It was aimed at measuring the impact of the Eger Summer School as well as to gather data for the next Summer School. Attitudes research was organized in the autumn of 2013. Serbian math teachers, who participated in Eger, were asked to complete the same questionnaire as used in the Tempus Attitude Survey (TAS) in order to establish their beliefs about math and also to evaluate their experiences of the Summer School in Eger 2013. In this qualitative interview research, 38 teachers completed the questionnaires. As teachers are widely accepted as role models who influence their students' development, their beliefs and attitudes were extremely important to us.

Most of the surveyed teachers were experienced teachers, with 10 or more years of teaching experience, and about 70% of the sample had attended more than 5 'events' (seminars, lectures, workshops etc.) at Eger's Summer School.

Eger's Summer School was highly rated (84% gave it the highest grade) and 66% thought that what they learned would be highly applicable to their everyday schoolwork.

Out of the particular events the most highly rated were the Teachers Day (94% gave it the highest rating), free time with other participants (92%), Family Day and workshops (87%), mathematical games (90%) and learning about specific mathematical applications and software (73%). Based on this feedback, more teacher presentations were included in the second Summer School held in Belgrade, 13th-27th July, 2014, as well as greater teacher participation in the Family Day. We also included more workshops, especially those connected with math software. It is noticeable that teachers think they should not only be given more guidelines for the processing of certain teaching methods, mathematical software and applications, but also for the processing of certain teaching units, curriculums and plans.

It is interesting to compare the responses of the teachers with their students. For example, 92,1% of the teachers believe that mathematics is essential for all humans, but only 60% of their students agree. 21% of the teachers believe that math is difficult and complicated compared to 26,32% of students. 94,74% are convinced that mathematics improves intelligence whereas only 75% of pupils concur with the statement. 88,84% of the teachers believe that the statement "Mathematics is not important for everyday life" is incorrect and 65,79% believe that mathematics is the most important course in school (of course!). They display a lot of self-confidence, arguing that Most teachers are very good (39,47). 71,05% do not believe that there is no way to get students interested in math, if she/he doesn't like the subject and 81,58% believe that mathematics could be taught in a more engaging way. Exactly the same percentage (81,58%) believes that computers should be used in math lessons. Furthermore, they (63,13%) stressed that the congested curriculum makes it difficult to teach math in a non-standard way. Problems that arise in the teaching of math are considered to be caused by:

Bad influence of general public/discouraging academic ambitions	28.95
Poorly designed and not adapted curricula	15.79
Bad influence of friends and family	13.16
Laziness of pupils	5.26
Computers and calculators	2.63
All of the above	34.21

Table 5.10: Common causes for difficulties in teaching
(Source: Klelija Zivkovic, Ljiljana Radovic)

One question directed only at the teachers concerned how their use of specific teaching aids/ methods changed after the Summer School. From their responses, it is clear that an improvement was made, particularly in connecting math teaching with art, using movies, individual games and playful activities and outdoor games, as well as in the use of math software and computer games.

Do you use any of these in math teaching?	Before Eger	After Eger
Computers	57,89	73,68
Math software	34,21	65,79
Presentations	57,89	63,16
Internet	52,63	60,53
Real physical objects and models	60,53	63,16
Computer games	7,89	28,95
Mathematical story-tales, anecdotes, historical facts	71,05	84,21
Individual Games and playful activities	28,95	68,42
Art-painting, sculpture	7,89	57,89
Art-music, dance	15,79	28,95
Art-movies	15,79	47,37
Art-situation games	15,79	34,21
Visits of science or art museums	44,74	50
Outdoor games	2,63	23,68
Work in groups and playful activities	71,05	76,32

Table 5.11: Teachers Klelija Zivkovic, Ruth Mateus-Berr

Despite this group being too small to draw any general conclusion, it is obvious that teachers need to cooperate more, exchange ideas and learn new methods. It is also evident that they liked to hear and learn how to include art in their teaching, and also to be taught how to use specific math software. Also, the importance of working with individual pupils should not be overlooked.

With seminars, teachers should be offered more workshop activities that can be applied in the classroom. Also, it is significant that they appreciate opportunities to listen to others teachers' experiences, ideas, lessons plan realization and suggestions.

5.3.5 University Students

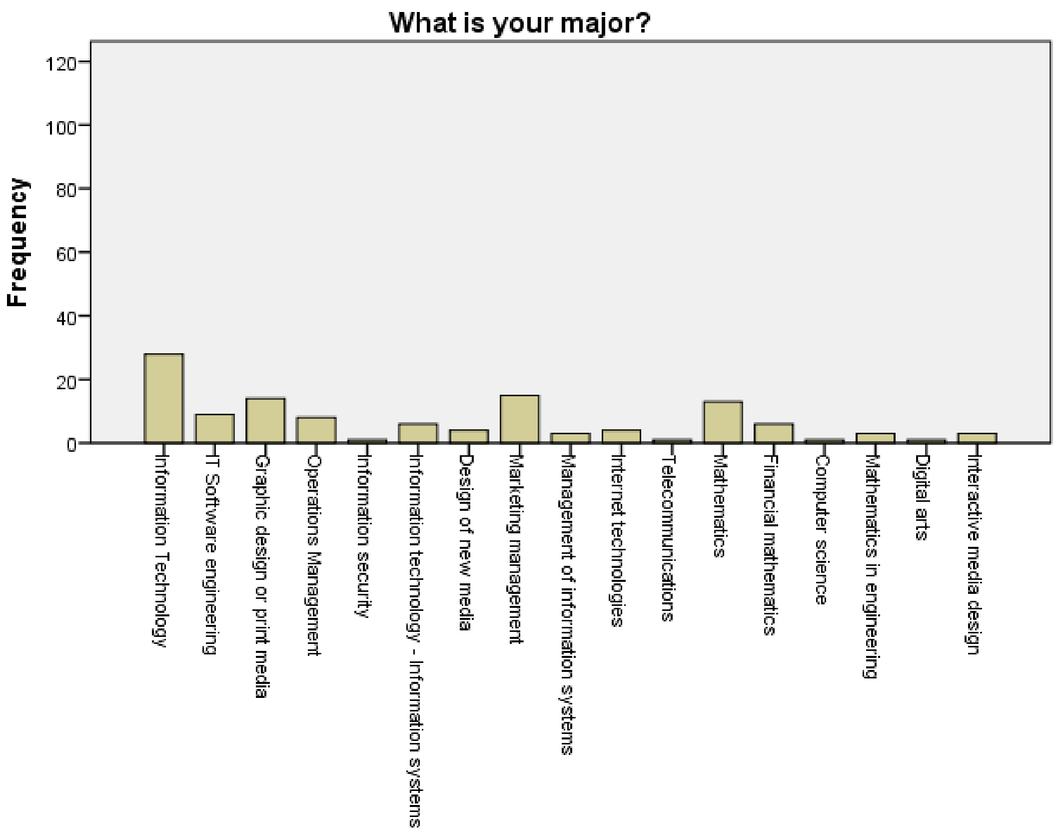

Figure 5.73: Major (Source: Klelija Zivkovic)

Major	Frequency
Interactive media design	3
Digital arts	1
Mathematics in engineering	3
Computer science	1
Financial mathematics	6
Mathematics	13
Telecommunication	1
Internet technologies	4
Management of information systems	3
Marketing management	15
Design of new media	4
Information technology – information systems	6
Information security	1
Operations management	8
Graphic design or print media	14
IT software engineering	9
Information technology	28

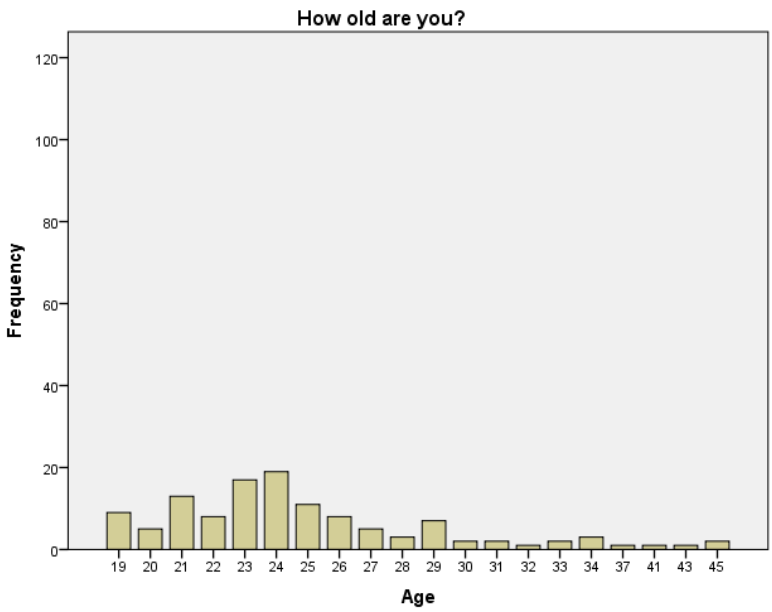

Figure 5.74: Age (Source: Klelija Zivkovic)

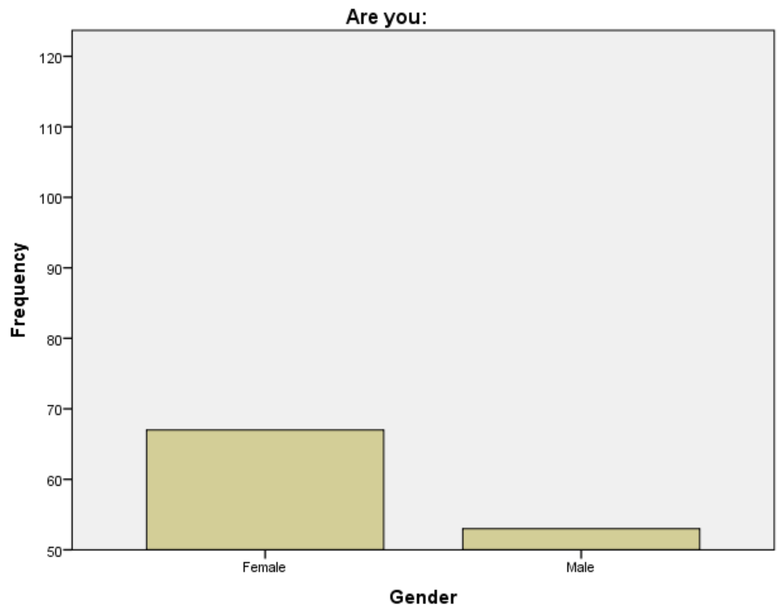

Figure 5.75: Gender (Source: Klelija Zivkovic)

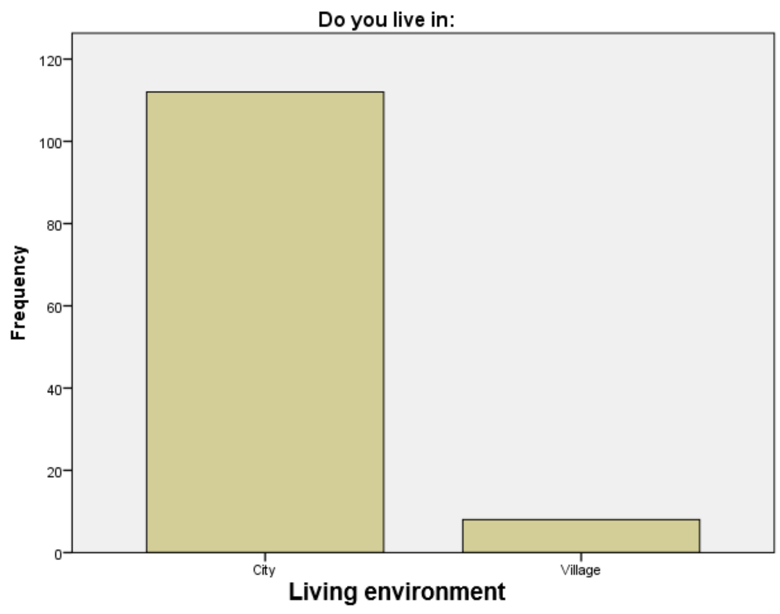

Figure 5.76: Living environment (Source: Klelija Zivkovic)

5.3.5.1 Grades

In the previous year, 24 students had an average grade at or close to the highest grade 10, 36 of them had an average grade close to 9, 17 students had an average grade close to 8, 8 students had an average grade close to 7 and only one had an average grade close to the lowest grade 6. There were 8 students who did not pass their mathematics exam the previous year and 27 students did not answer this question. (Figure 5.77) Most of the female participants who answered this question had either not taken a math exam, or not passed, whereas most males had passed and achieved average grades from 6–10. (Figure 5.78) As for their satisfaction with their grades, 78 students answered that they are happy with their math grades. In contrast to this, 18 answered that they are discontent with their grades and 24 remained neutral. One person did not provide an answer. (Figure 5.79)

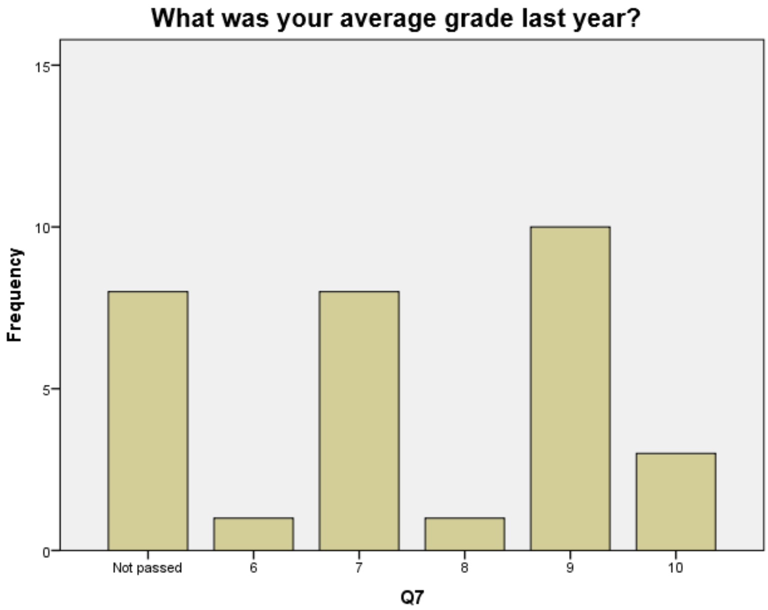

Figure 5.77: Average grade last year (Source: Klelija Zivkovic)

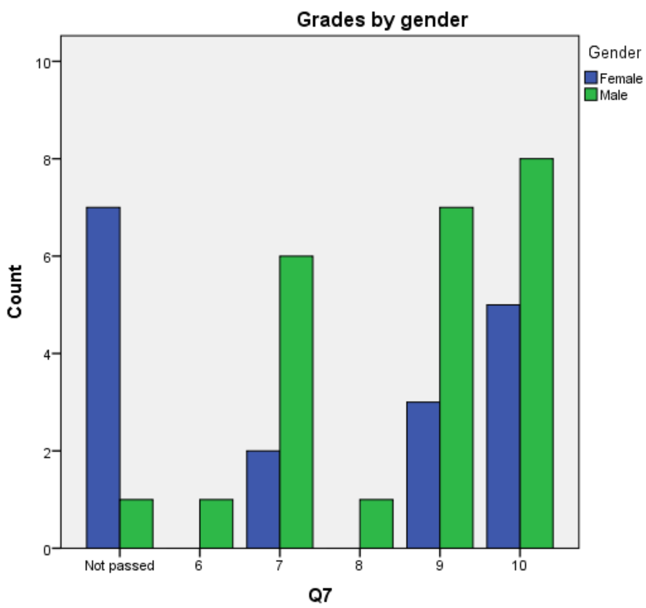

Figure 5.78: Average grade by gender (Source: Klelija Zivkovic)

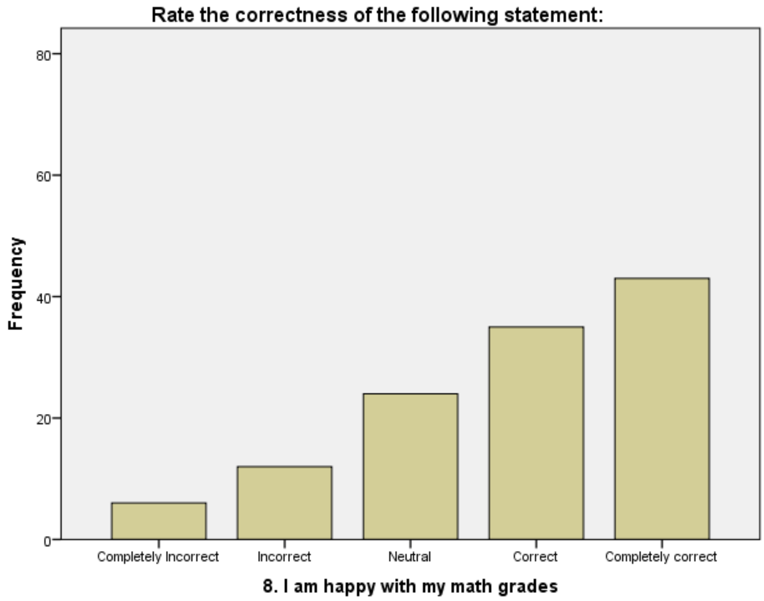

Figure 5.79: Math grades satisfaction (Source: Klelija Zivkovic)

5.3.5.2 Studying Habits

In terms of their individual studying habits, the majority of the surveyed students had to take extra curricular math classes. When asked whether they took extra math classes 50 of them answered *Yes*, 16 answered *"A few times"* and 5 answered *"All the time"*, whereas 49 students never took extra math classes. (Figure 5.81) In addition to this, when asked how much help they required with their homework, most students (74) replied that they did not need help with their homework, 24 students answered neutral and 22 students answered that they always required help with their homework. One person did not answer either question. (Figure 5.80)

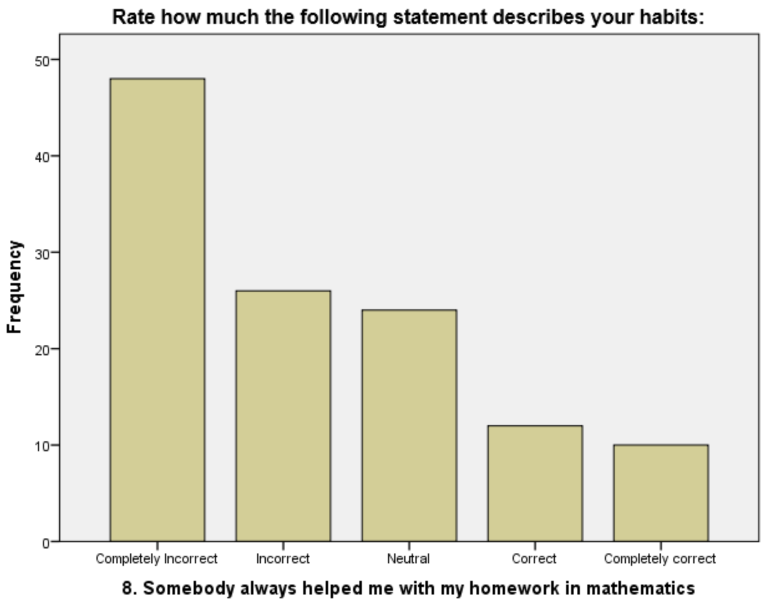

Figure 5.80: Studying habits/Help with homework (Source: Klelija Zivkovic)

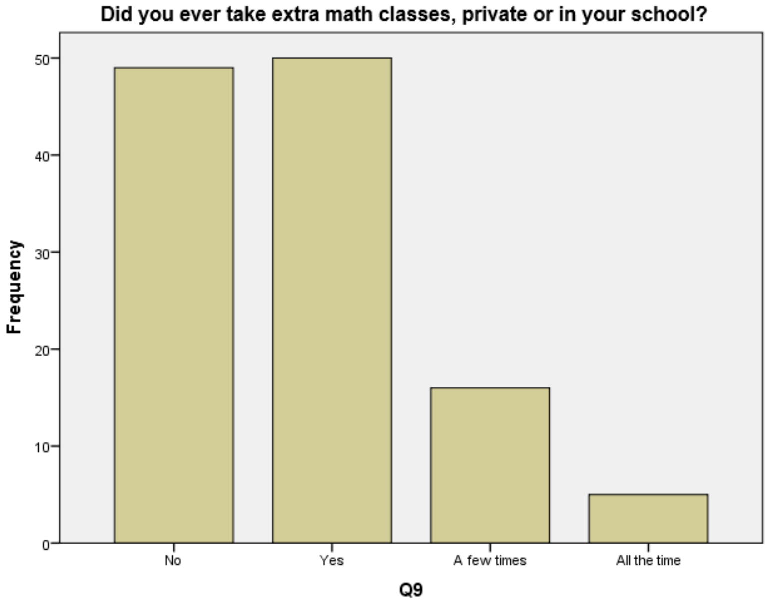

Figure 5.81: Extra math classes frequency (Source: Klelija Zivkovic)

5.3.5.3 Attitudes and Beliefs

In spite of their varied majors, the majority of the students (81) agreed that math is essential for all humans. Out of the remaining 40, 32 remained neutral, 7 disagreed and 1 did not answer the question. (Figure 5.82) In addition to this, a large proportion of the students (47) disagreed with the statement that mathematics is difficult and hard. A lower number remained neutral (41) and the remaining 32 agreed with it. One person did not provide an answer. (Figure 5.83) Interestingly, and quite possibly expectedly so when observing the previous answers, the majority of the students (99) agreed with the statement that mathematics improves intelligence. 17 remained neutral and only 4 students disagreed. One person did not provide an answer. (Figure 5.84)

73 of the surveyed students disagreed with the statement that mathematics is not important for everyday life, 26 remained neutral and 21 agreed with it. One person did not provide an answer. (Figure 5.85) However, when asked if math is the most important course in school, most of the students (50) remained neutral, 33 disagreed and 37 agreed. One person did not provide an answer. (Figure 5.86) Again, most of the students (56) remained neutral when asked whether knowing math opens doors for future careers, 26 of them disagreed and 38 agreed with the statement. One person did not provide an answer. (Figure 5.87)

50 students confirmed that mathematics was always easy for them, while 45 remained neutral and 25 disagreed. One person did not provide an answer. (Figure 5.88) Similar to this, 67 students disagreed that math was taught to unsatisfactorily and 24 agreed. 29 students remained neutral and one did not provide an answer. (Figure 5.89)

As one would expect, 79 students did not feel that classes in mathematics were a complete waste of time for them, 19 remained neutral and 12 did indeed feel that studying math was a waste of their time. One person did not answer. (Figure 5.90)

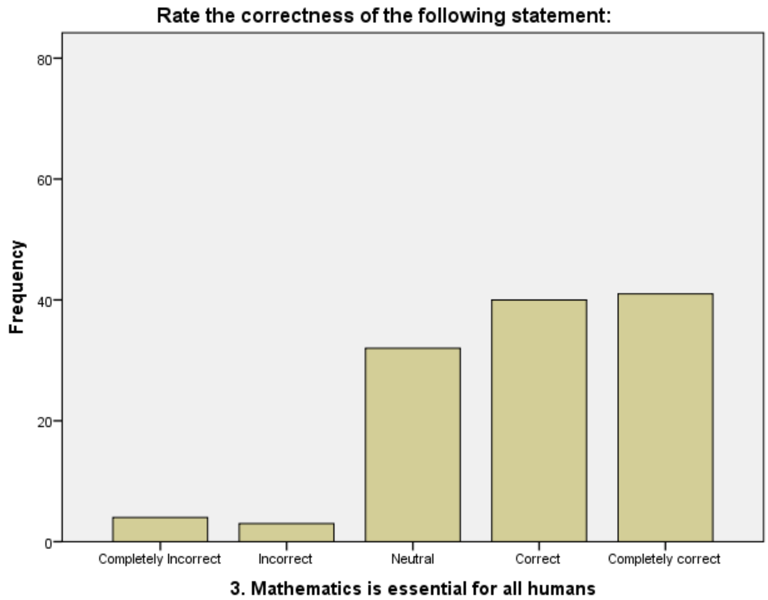

Figure 5.82: Mathematics is essential for all humans (Source: Klelija Zivkovic)

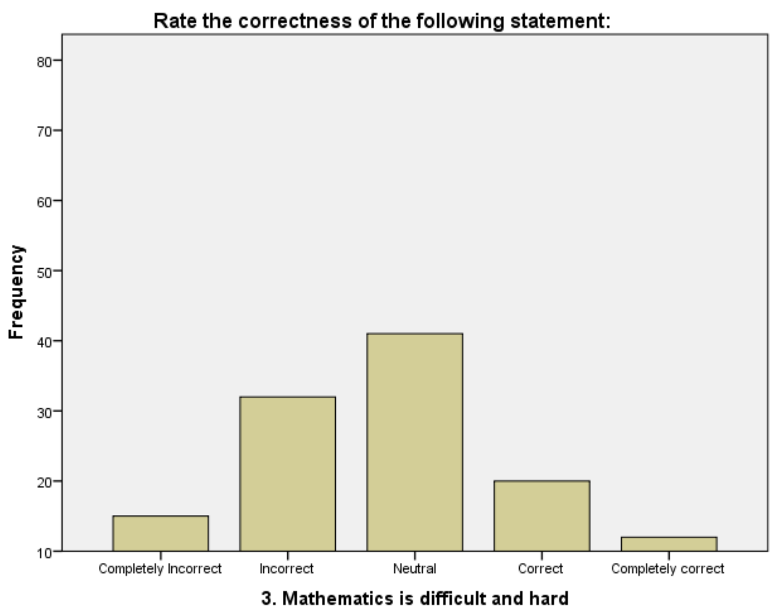

Figure 5.83: Mathematics is difficult and hard (Source: Klelija Zivkovic)

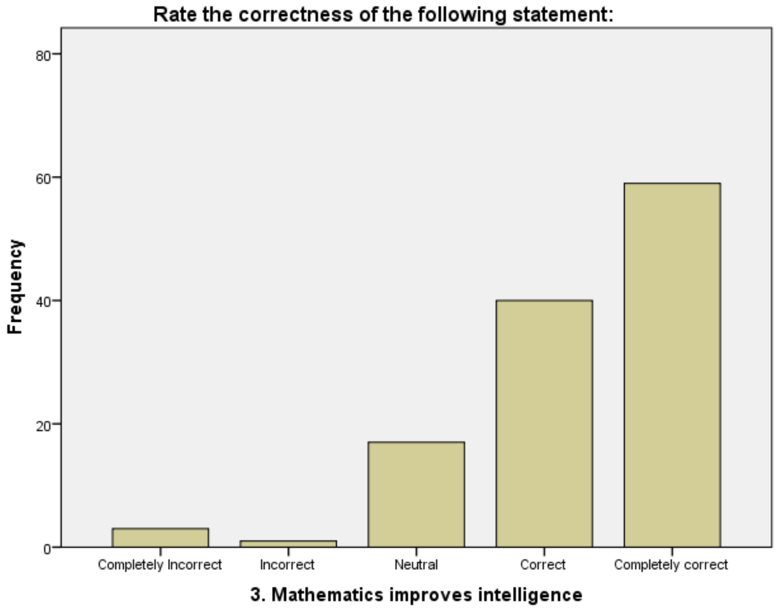

Figure 5.84: Mathematics improves intelligence (Source: Klelija Zivkovic)

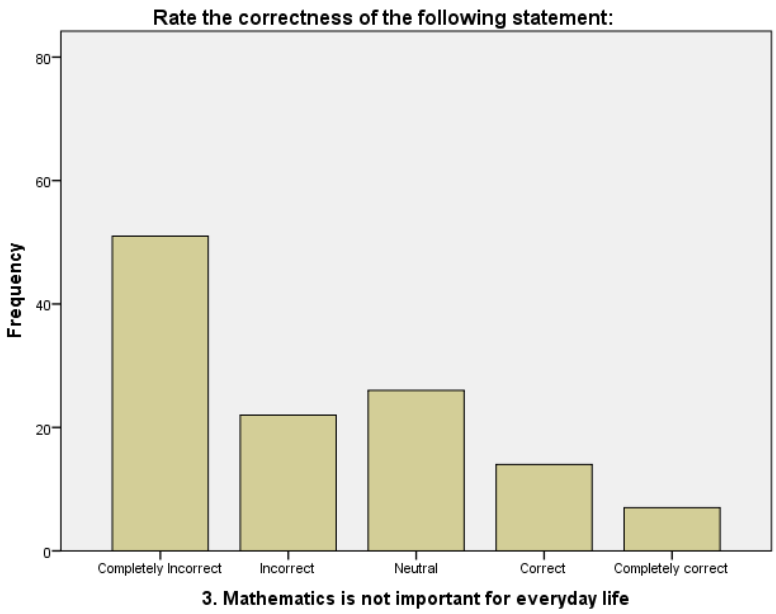

Figure 5.85: Mathematics is not important for everyday life (Source: Klelija Zivkovic)

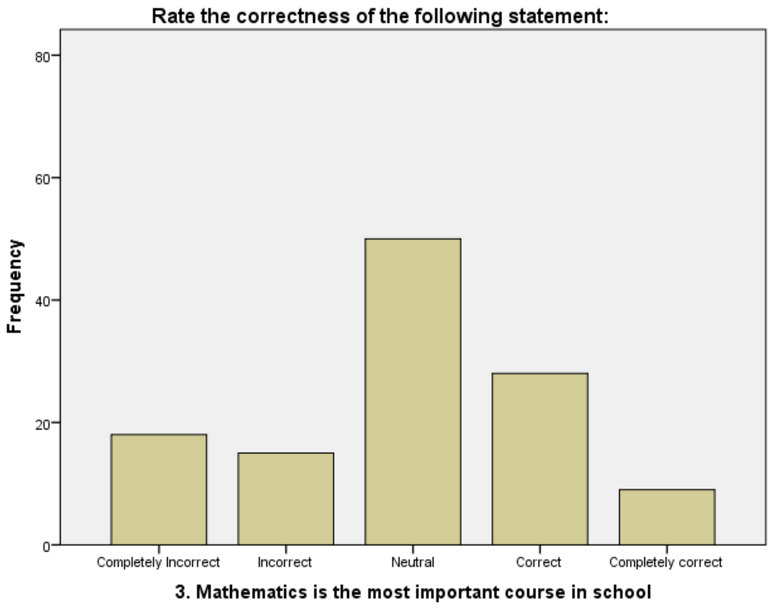

Figure 5.86: Mathematics is the most important course in school
(Source: Klelija Zivkovic)

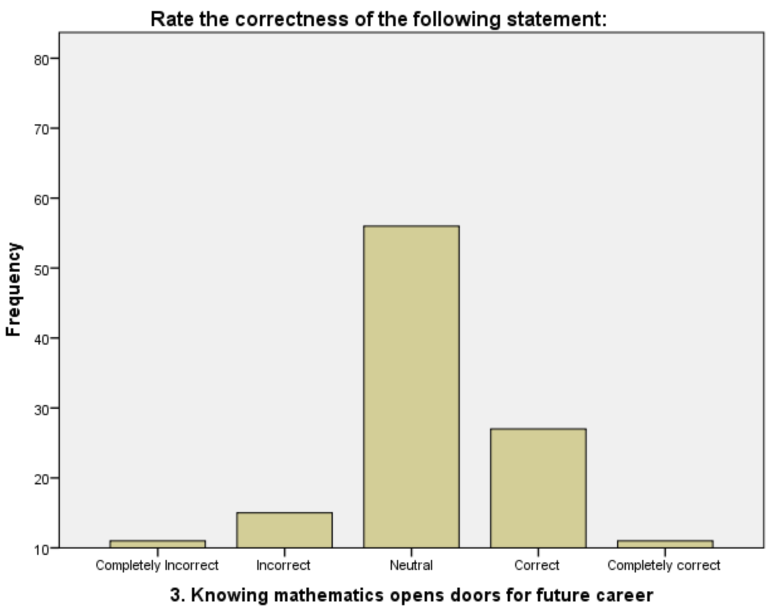

Figure 5.87: Knowing mathematics opens doors for a future career
(Source: Klelija Zivkovic)

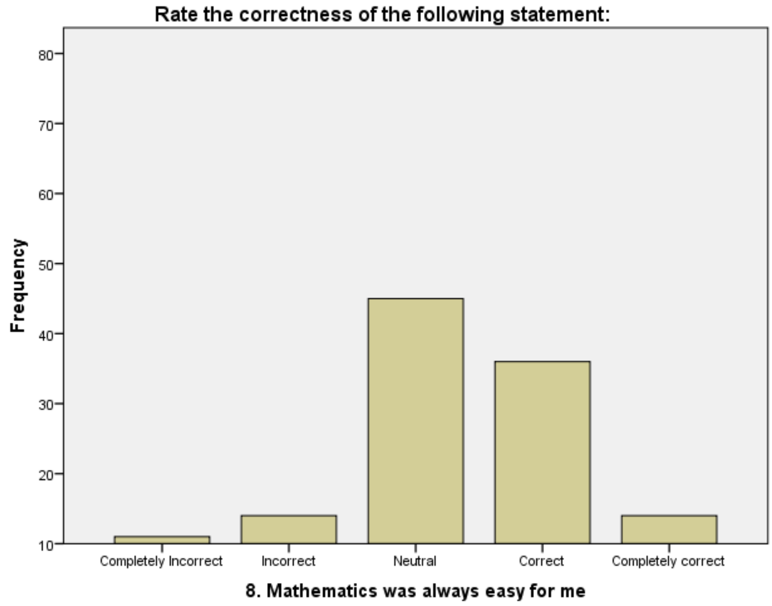

Figure 5.88: Mathematics was always easy for me (Source: Klelija Zivkovic)

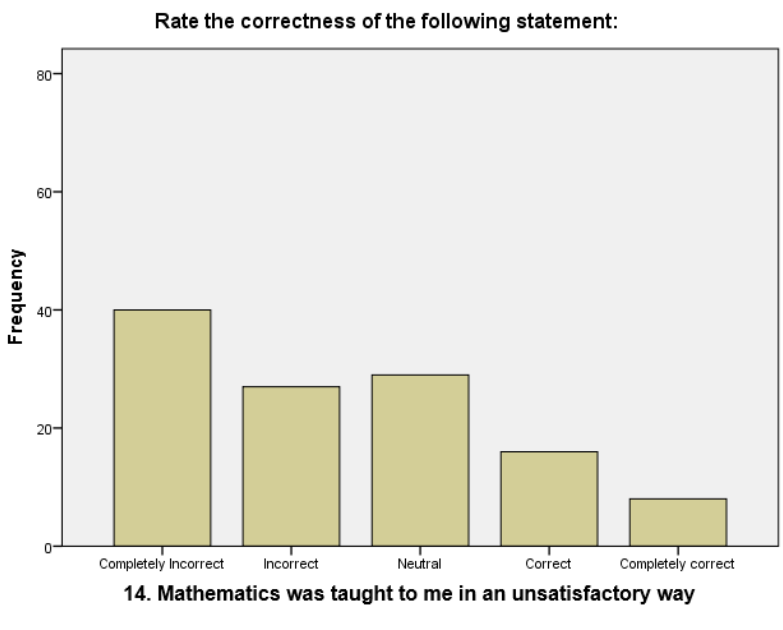

Figure 5.89: Math was taught to me in an unsatisfactory way (Source: Klelija Zivkovic)

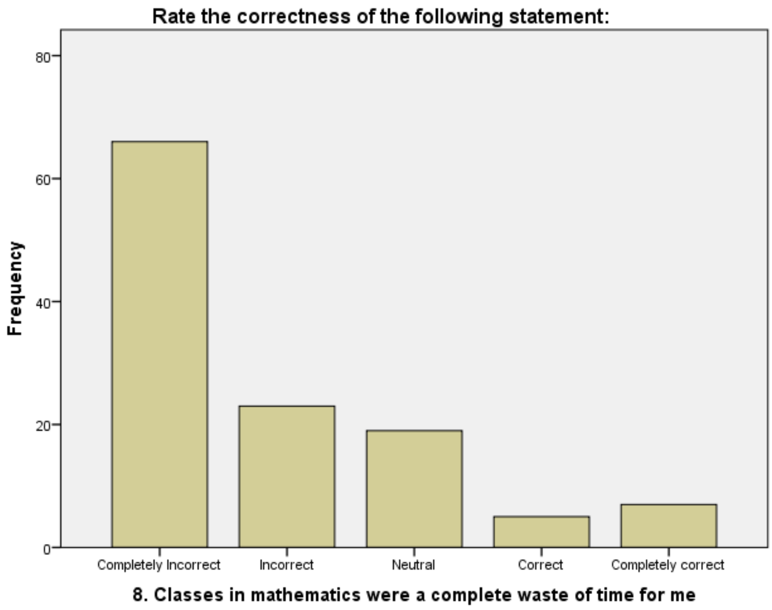

Figure 5.90: Math classes were a complete waste of time for me (Source: Klelija Zivkovic)

5.3.5.4 Teaching

85.8% of the students were positive that mathematics could be taught in a better way. Almost 11% were neutral and 3.3% disagreed with it. Interestingly, no one answered "completely incorrect", which suggests that no one in the surveyed demographic found the present method of teaching math completely satisfactory. One person did not answer. (Figure 5.91) Similarly, a large proportion of the surveyed students (68.3%) felt that most people were bored in math classes, 22.5% remained neutral and 9.2% disagreed with this statement. One person did not answer. (Figure 5.92) In relation to the previous questions, only 17.5% of the students agreed that most teachers of mathematics are very good, whereas 47.5% disagreed; 35% remained neutral, and one person did not answer. (Figure 5.93) Finally, 70.5% of the students believed that they could have learnt more mathematics if it was presented in a better way. 15.8% remained neutral on this question and 13.3% disagreed with this statement. One person did not answer. (Figure 5.94)

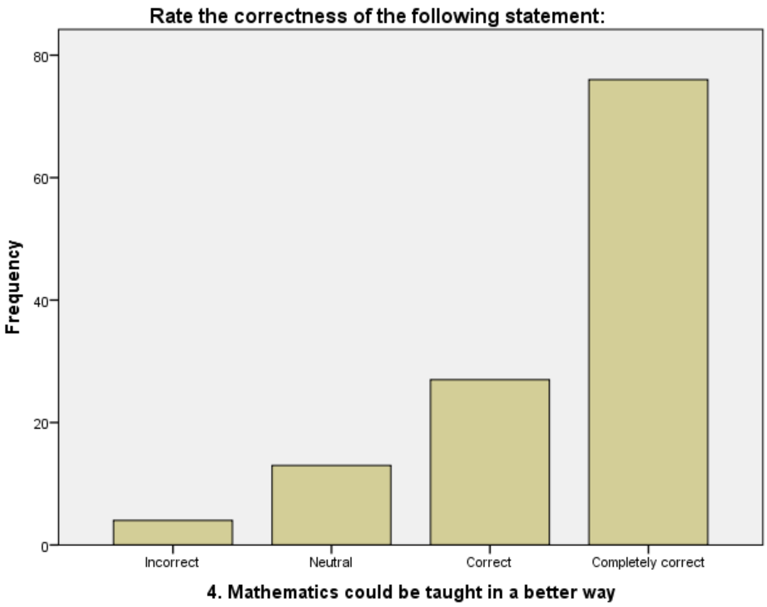

Figure 5.91: Mathematics could be taught in a better way
(Source: Klelija Zivkovic)

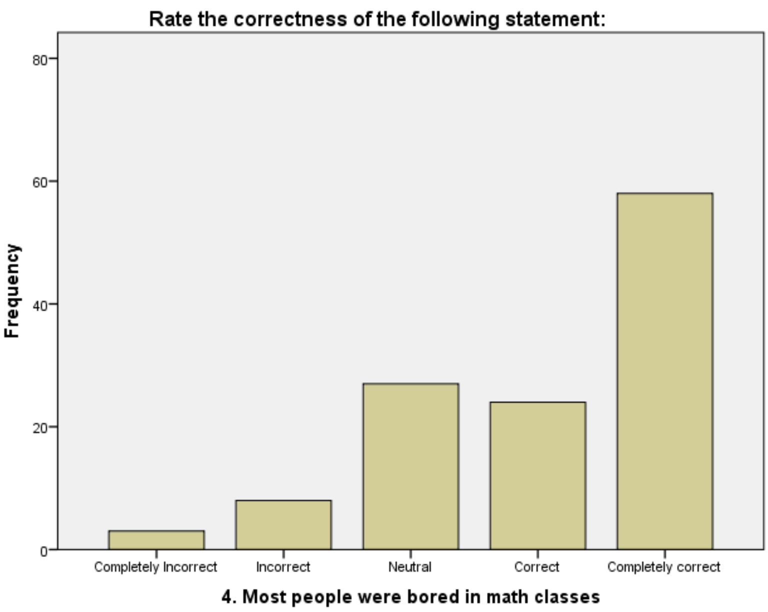

Figure 5.92: Most people were bored in math classes (Source: Klelija Zivkovic)

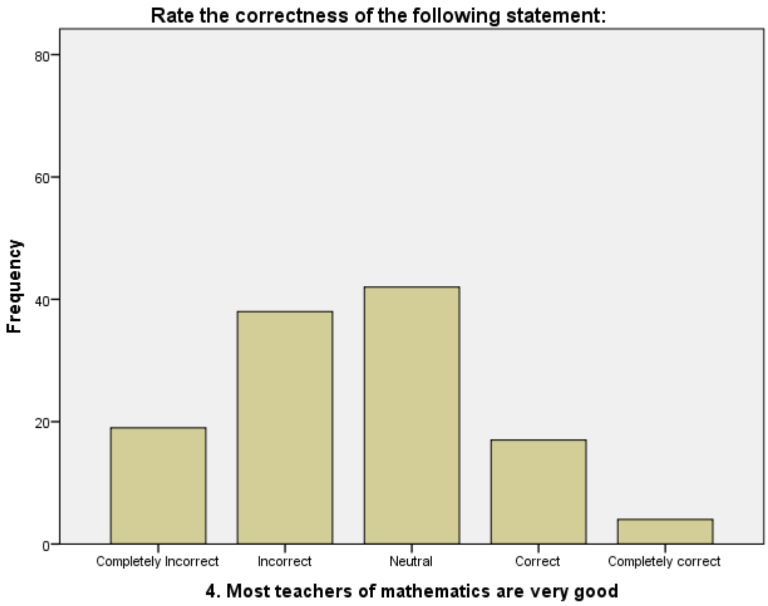

Figure 5.93: Most teachers of mathematics are very good (Source: Klelija Zivkovic)

Figure 5.94: We could have learnt more mathematics if it was presented in a better way (Source: Klelija Zivkovic)

5.3.5.5 Education

When asked how prepared in math students feel after their education, 80% (96 students) replied that they felt that their education prepared them for the mathematics they would need, whereas the remaining 20% (24 students) did not feel the same way. One person did not answer. (Figure 5.95) Furthermore, 46 students disagreed with the statement that there is not enough math in school. Similarly, 43 remained neutral and 31 agreed. One person did not provide an answer. (Figure 5.96)Furthermore, 72.5% felt like they learnt a lot of mathematics during their education, and only 27.5% felt this was not the case. One person did not answer. (Figure 5.97)

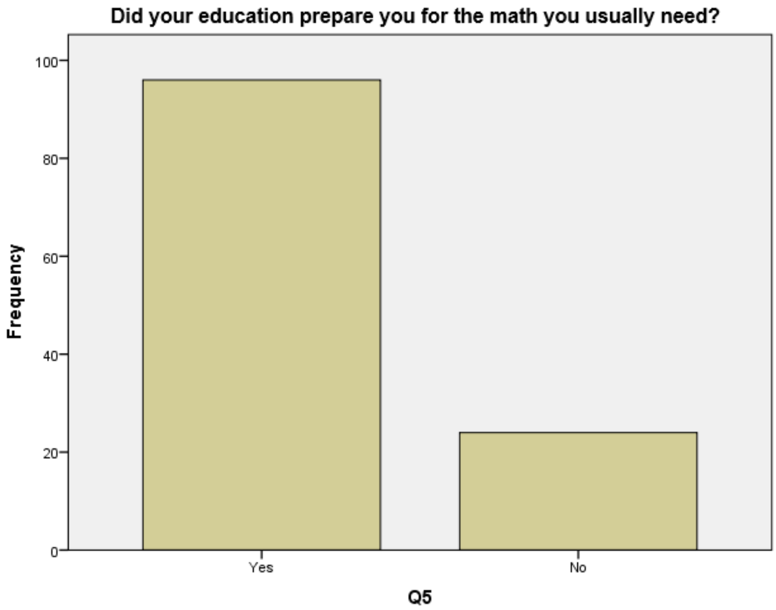

Figure 5.95: Did your education prepare you for the math you usually need? (Source: Klelija Zivkovic)

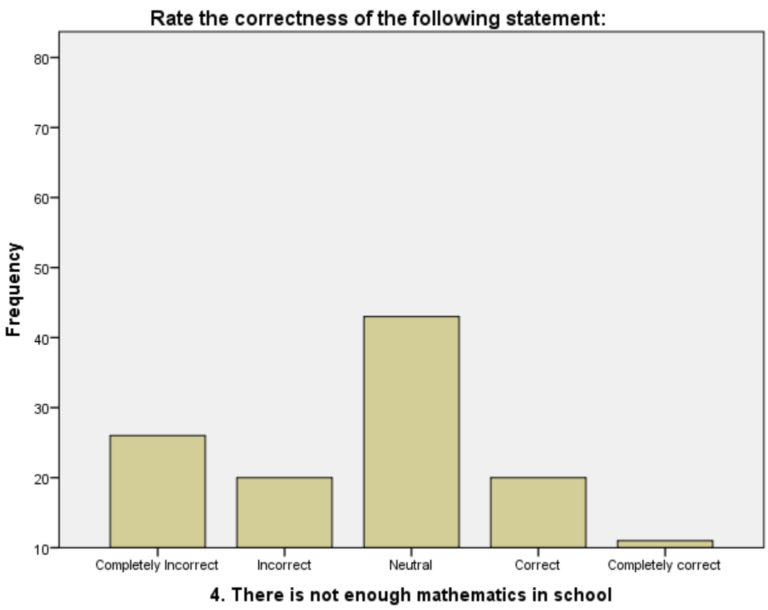

Figure 5.96: There is not enough mathematics in school (Source: Klelija Zivkovic)

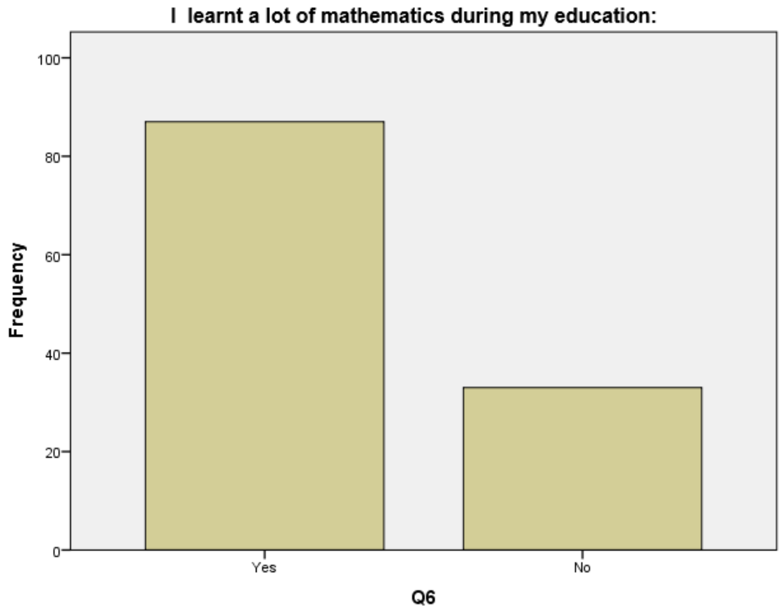

Figure 5.97: I learnt a lot of math during my education
(Source: Klelija Zivkovic)

5.3.5.6 Parents

The graphs show that most students believe that their parents do in fact use math every day. What is interesting is that as the parents' level of educational attainment rises, so does the students' belief that their use of math in their everyday life increases as well. Furthermore, the bar signifying everyday use of math seems to reach its highest in university-educated mothers, but in the fathers' case, it reaches the highest with high school-educated fathers. (Figure 5.98) This is interesting because only 50.9% of the students' fathers are university educated, and 43.9% are educated to high school level (Figure 5.99), whereas in the case of the mothers, both university-educated and high-school educated mothers make up 47% each respectively. (Figure 5.100)

Almost half of the demographic (49.2%) answered positive when asked if their parents think mathematics is important for everyday life, while 35% remained neutral and 15.8% replied in the negative. (Figure 5.101) Similarly, 51.6% answered that their parents think it is important to know mathematics, 17.5% answered negatively and 30.8 remained neutral. One person did not answer. (Figure 5.102)

Moreover, 72.5% of the students believe that their parents are happy with their mathematics knowledge, 17.5% were neutral and 10% answered negatively. (Figure 5.103) Furthermore, 70% of the students believe that their parents are happy with their math grades, 18.3% remained neutral and 11.7% believed that their parents are unhappy with their mathematics knowledge.

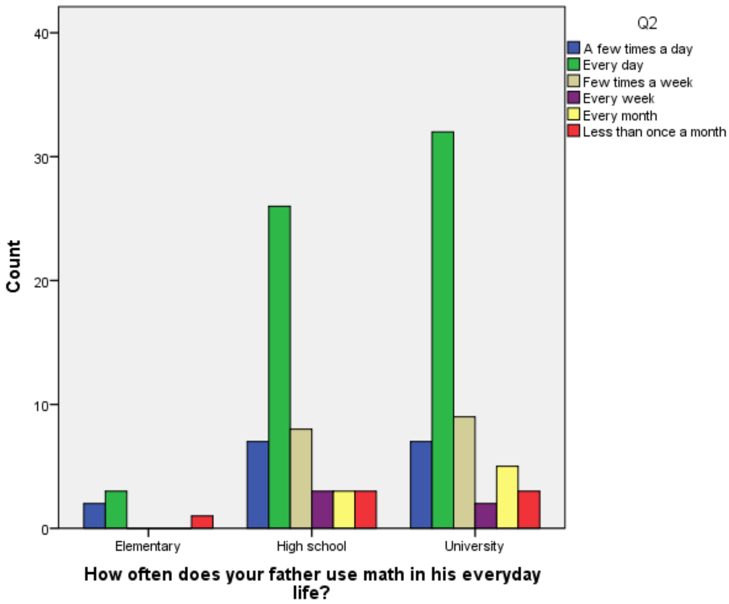

Figure 5.98: Father's everyday use of math (Source: Klelija Zivkovic)

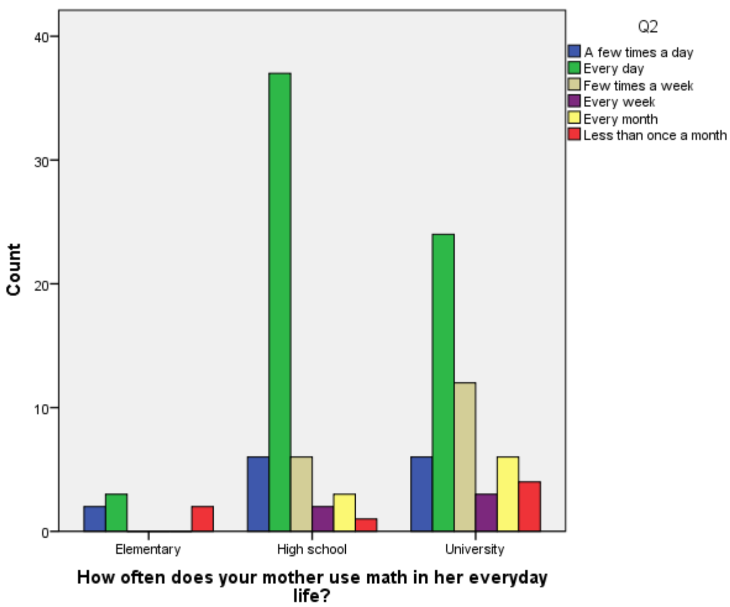

Figure 5.99: Mother's everyday use of math (Source: Klelija Zivkovic)

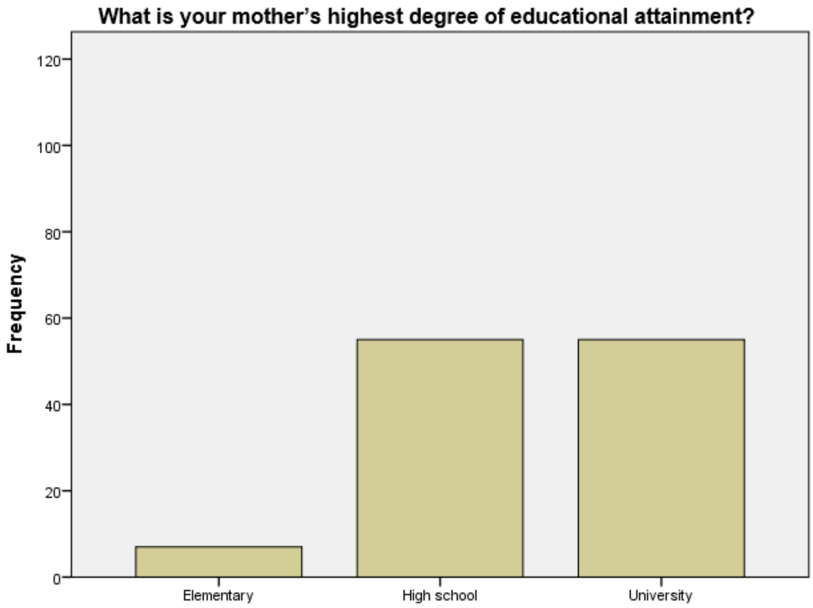

Figure 5.100: Mother's highest level of educational attainment
(Source: Klelija Zivkovic)

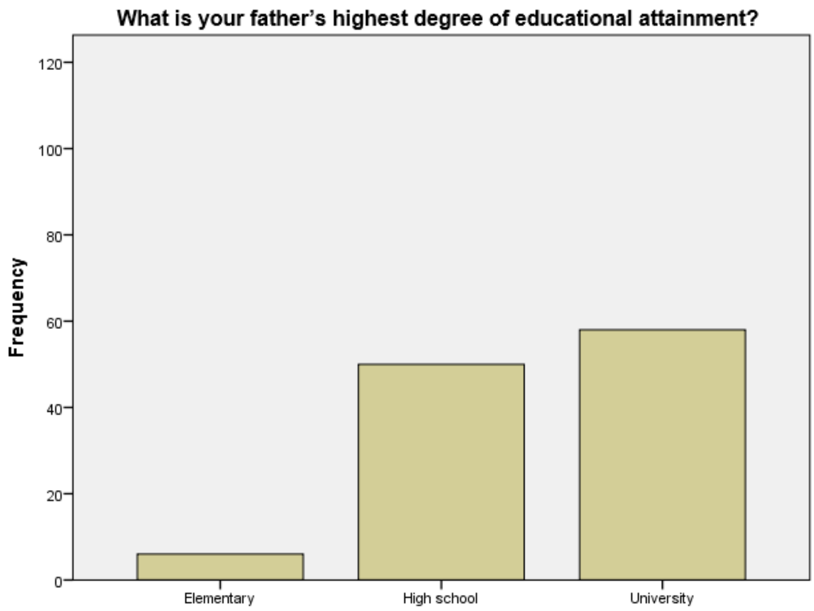

Figure 5.101: Father's highest level of educational attainment
(Source: Klelija Zivkovic)

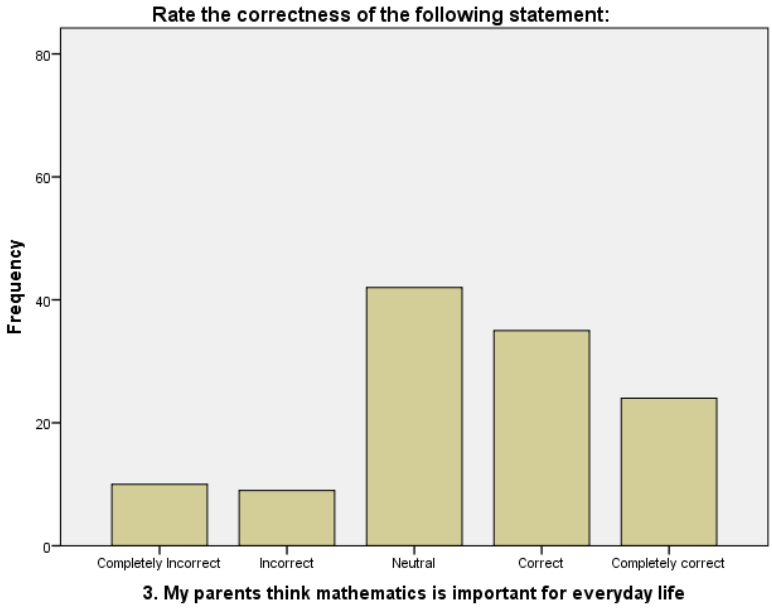

Figure 5.102: My parents think math is important for everyday life
(Source: Klelija Zivkovic)

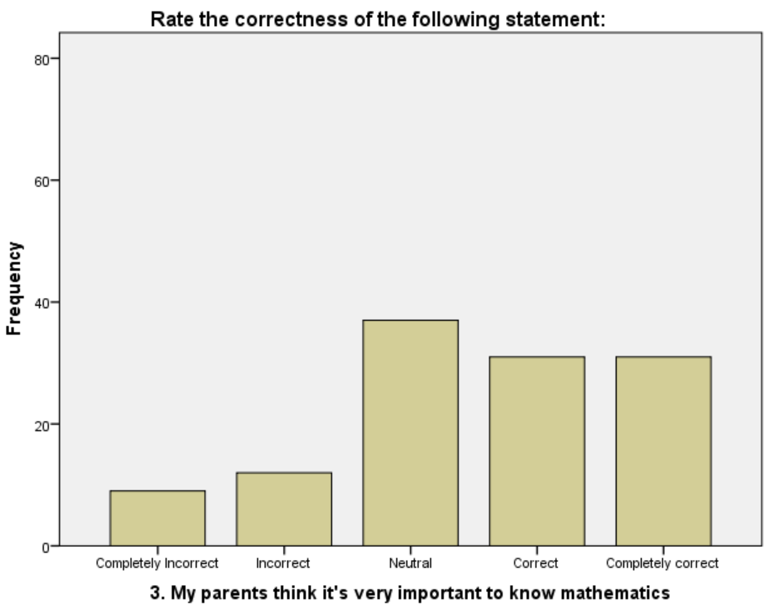

Figure 5.103: My parents think it is very important to know mathematics
(Source: Klelija Zivkovic)

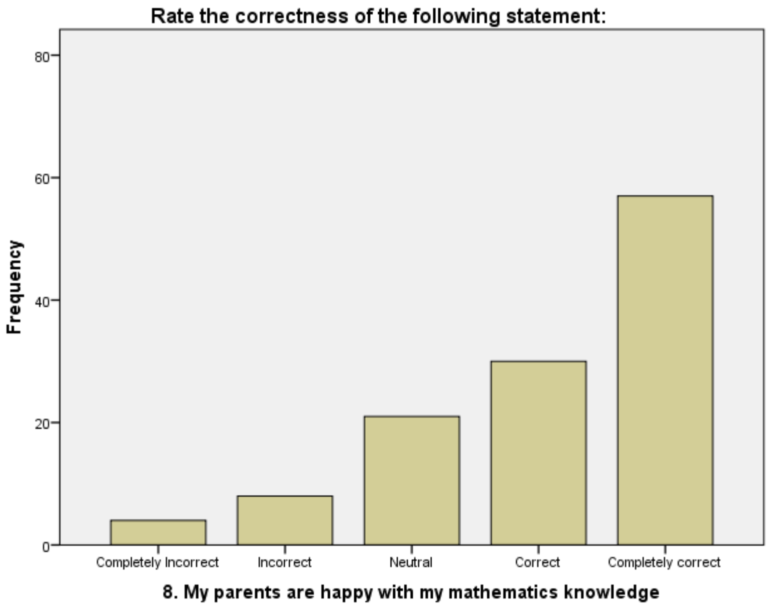

Figure 5.104: My parents are happy with my mathematics knowledge (Source: Klelija Zivkovic)

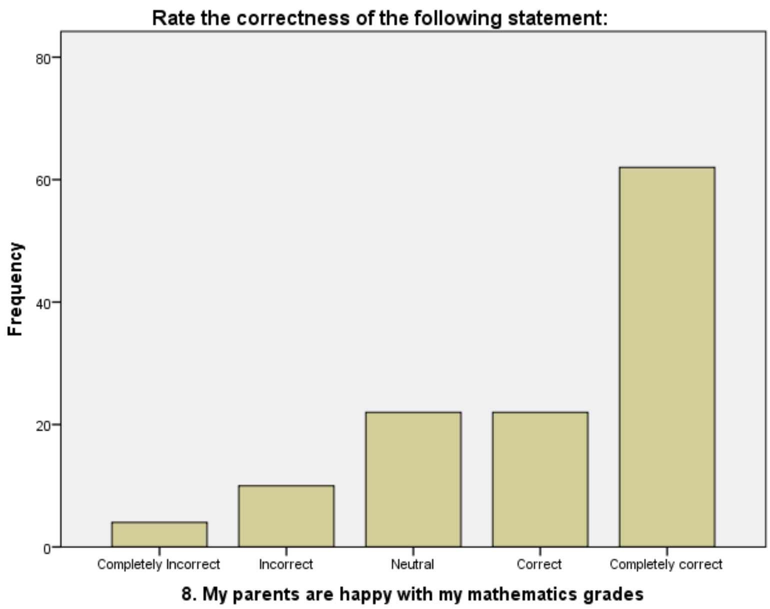

Figure 5.105: My parents are happy with my mathematics grades (Source: Klelija Zivkovic)

5.4 Discussion and Recommendations

The Data Analysis researched the following domains: Attitudes (beliefs, motivation) of Students (elementary, high school, university), Influence of Parental homes, Teachers attitudes, Teaching itself. Starting from the essential point of the acknowledgment of cultural diversity, environmental diversity and especially the individual diversity of students will be discussed as crucial insights at Discussion and Recommendations as well as misunderstandings, which might have led to insufficient implementation as: #Real-Life: #Personalized learning and multiple intelligences based and #Interdisciplinarity as further described.

The main objective of the surveys of 2013 and 2014 was to measure initial attitudes toward mathematics of students in general but also towards mathematical education and, in particular, to mathematical education in Serbia. The crucial Summer School in Eger should provide input to teachers by encouraging them to use ICT, playful visual-spatial, bodily-kinesthetic tools and approaches through the arts. Whereas the survey of 2013 can be regarded as a current situation analysis, the survey of 2014 analyzed possible improvements in teaching and especially the expanded application of ICT and visual-spatial, bodily-kinesthetic tools in math classes. Here it must be pointed out that attitude change attitudes in teacher education need to be analyzed with long-term studies; the survey of 2014 can only give us a brief insight, also that the pupils interviewed differed in 2014 from those of 2013. Further, it must be considered that not all students involved in the survey of 2014 have been taught mathematics by teachers who participated at the Summer School in Eger, 2013. For that reason the results might be regarded as a similar current situation analysis and show slightly similar results as the survey of 2013.

It was demonstrated that even through small interventions in teacher training (Summer School, 2013) attitudes changed and new teaching strategies were developed. Further student attitude research should be undertaken in the upcoming years and regular teacher training scheduled.

The outcomes of the research should have an impact on teacher training and should guarantee finance for lifelong learning and teaching tools by the Government and responsible institutions. After the Summer School in Eger, at least 30 out of 40 teachers designed more than 60 playful and computer-based math lessons, including Powerpoint presentations and others (http://vismath.ektf.hu/index.php?l=en&m=311) and many presented highly motivating and innovative teaching approaches at the Summer School and closing conference in Belgrade. The research team remains confident that these open sources will spread and facilitate changes in classroom teaching and influence teacher education at secondary and tertiary level.

Comparing the application of ICT in 2013 and 2014, teachers did not increase their use of computer media: in 2013 a third of the students used computer media in the classroom, in 2014 just 21%. Again, here it must be pointed out that attitude changes in teacher education must be analyzed with long-term studies and the survey of 2014 can only give us a brief glimpse. Further research is needed examining why teachers could not change their teaching practice: What challenges do teachers in Serbia face? How large are the classes? How well-equipped are individual schools when it comes to hardware and software? If they develop tool kits, who provides financing?

Concerning visits to museums, again the particular conditions need to be analyzed: in Austria, for instance, there are cases when even art teachers do not make regular visits to museums with their classes, as such trips depend on school directors, administrators, staff representatives and the school community; the setting of priorities; and last, but not least, it also depends on the ability of students and parents to pay admission fees and travelling costs.

A recent study published by the London School of Economics compared achievement estimates for the same students across curriculum subjects, and found that instructional time has a positive and significant effect on achievement (Lavy, 2010). In Serbia, in fourth grade, 778 (18.5) hours per year are allocated to mathematics instruction compared to the international average of 897 (2.0) (Mullis et al. 2012, 345). 8 (out of an average of 13) TIMSS mathematic topics were taught to all or almost all students by the end of the fourth grade (Mullis et al. 2012, 364). Of course, surveys like TIMSS provide important information on countries' achievements, but these tests also put teachers under pressure to perform and impose time constraints. In order to facilitate the application of new learning materials, learning strategies used in TEMPUS should be included in the test assessment or at least a focus on learning strategies in general.

Teamwork is considered to have a positive impact on students' results, but it must be taken into account that teamwork demands extra time. If overtime cannot be paid for financial reasons, then it should be compensated in the form of competitions, awards, material production (for example: toolkits) and concessions on school timetables. According to the Society of Human Resource Management, appreciation is at least as important as salary, it works as an "emotional salary" (Lengyel-Sigl 2014, K12; Krishnamoorthy 2014).

5.4.1 Attitudes (Beliefs, Motivation) of Students

Acknowledgment of

a) Cultural Diversity

Understandings of mathematics emerge through interplay between all school partners: teachers, students, parents and their societal background. Their constructions derive from a variety of culturally based assumptions as to the nature of mathematics and to the associated forms of accountability they produce.

Further, it has been shown that children from diverse cultural groups develop their own inquiries into science (Bell 2009, 294-295), such as math. They need specific learning environments regarding their social-historical background. If diversity is approached in an interdisciplinary way as mentioned above, interest is aroused and translations take place, thus good development can be expected.

b) Environmental Diversity

Besides cultural diversity, contextual environments determine understanding. For example: children who grew up in the city have different approaches to children that grew up in the countryside.

c) Individual Diversity

Students not only differ in their individual interests e.g. youth-culture: music, lifestyle, etc. but also identify with diverse learning methods: verbal-linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical-rhythmic, interpersonal, intrapersonal, naturalist (Gardner 1993, Jenkins & Nebraska 2006, 31). In this research work the focus was placed on visual-spatial and bodily-kinesthetic learning attitudes. The findings proved that these two learning styles are scarcely touched upon in the average math class. It is recommended that one teaching task e.g. quotations should be prepared with different learning taxonomies regarding all diverse learning types, otherwise a large percentage of students will not achieve. Open-collaborative learning should be prepared regarding different learning types and the math teacher switch their role to that of mentor rather than explainer.

5.4.2 Parental Homes

Parental homes determine to a large degree students' beliefs about, and performance in, mathematics. In Serbia, students seem to be encouraged by their parents when they express satisfaction with their grades. Students believe that their parents have to use a little less mathematics in their daily lives than students. As parents' expectations were not surveyed, we can only interpret students' beliefs about their parents' attitudes to the subject. Further topics, which were analyzed, for example in TIMSS 2011, such as school discipline (versus problems in the parental home) and students bullied at school (versus support from home) cannot be discussed here because they were not included in the questionnaire and nor were the impact of hunger and lack of sleep. Where the parents of the surveyed pupils were engaged in mathematics (fathers more than mothers regarding academic interest), students in Serbia also tended (as everywhere) to see their parents as important role models for their career.

5.4.3 Teachers & Teaching

Teacher Training

Attitudes to mathematics form very early, in preschool. Already preschool teachers determine a pupil's attitude towards mathematics. Pupils can be influenced merely by teachers recounting their own experiences. "The foundation for understanding mathematical concepts related to number sense begins at early ages, and the basis of mathematical skills that will be needed later in life can be presented in early childhood settings" (Aslan et al. 2013, 1-2). Mathematical concepts and ideas surround us, and children engage with these surroundings from early on (Stafford, 2010). Teachers refer to their own experiences and are required to teach various subjects in preschool and elementary school, many of them are not specialized and thus are not especially competent in the subject. Raymond (1993) suggested that "teachers' mathematical beliefs are influenced by previous school experiences, teachers, current practice and teacher education courses". Teachers' "mathematical beliefs affect students'" learning (Kagan, 1992, 65-90) and in turn students "perceptions of subjects" (Carter & Norwood, 1997; cited in Yesil-Dagli, Lake & Jones, 2010).

In the light of the survey results from the Applied Design Thinking Workshops held at the Summer Schools in Eger 2013 and in Belgrade 2014 another issue can be identified: teachers of mathematics may well belong to the logical-mathematical learning type and therefore find it difficult to approach different learning attitudes and empathize with the needs of other learning types. They seem to "stay inside their box", not unlike the group that does not consider itself talented or interested in math. How can, then, these preconceptions be overcome and cooperation be supported, allowing individuals to look beyond their own narrow enclosure? Empathizing with students concerning their particular learning types is suggested. It is recommended that vocational teacher training courses are offered, which develop interpersonal skills. Highest academic knowledge, subject specific didactics (Coaktiv-Studie 2009) but also empathy and verbal skills in teacher education is needed (Colosimo 1984, Hattie 2013, 137) and Hattie believes that if one of the above elements is missing, efficiency of learning is reduced by more then one third.

Visual-spatial learning types and ICT approaches

As well as students learning and understanding more easily when tasks are visualized, their motivation also increases. Applications as computer-based visual tools in schools have been researched by Hattie: first of all, what is meant by “application of computers” has to be clarified. Hattie (2013, 259-278) carried out 76 meta-analyses of 4875 research studies in which a total of 3990028 pupils participated. Computer application was identified with tutoring, managing, simulation, enrichment, programming and problem-solving. In 60 out of 100 cases he could prove that positive learning change (attitude towards learning and school) takes place due to computer-based teaching (2013, 261). Computer-based learning occurs at schools where a large degree of teacher awareness exists for multiple and diverse learning strategies and taxonomies, where there are pre-trainings of computer knowledge as a teaching and learning tool, where multiple learning environments exist, where students control their learning (time-management, individual pace, adaption of learning material, selection of tasks, testing) and not the teachers (teachers as mentors!), where peer-groups are supported and feedback (explanations are more effective than simple responses (Timmermann & Kruepke 2006)) of teachers was optimized (Hattie 2013, 261. Translation by the author). In teacher training it was observed that teachers are trained by professors who are not very familiar with new media and therefore are not recognized as convincing role-models (Hattie 2013, 263). Baker & Dwyer (2000) analyzed the impact visualization had on learning outcomes by teaching the same task one with visualization and the other without; their findings led them to the conclusion that a visual demonstration can transfer the core of a learning task to students. Clark & Angert (1980) conducted a meta-analysis of the efficiency of images in learning surroundings by researching production, shadow, context, decoration, color saturation. Illustrated material was much more effective then verbal description, especially for high school students (Hattie 2013, 269). Frey & Fisher (2008, 15) stress that recent research concerning the benefits of using color in presentations proved that color visuals increase the motivation to read and participation by up to 80% and enhances learning as well as improving retention by more than 75%. Visual-media methods (for example TV, movie, video application in the classroom etc.) did prove very little learning effects as well as multi-media methods (Willet et. al 1983; Blanchard et. al 1999; Hattie 2013, 270). Hoeffler & Leutner (2007) came to the conclusion that animated images have a greater impact than static ones (Hattie 2013, 245). Graphic organizers in presentations were proved to help dyslexic and right-brain learners (Petty 2009, 115). Last but not least, we believe that visual language is very close to the brain’s “natural” language as described with “mentalese” or metaphors (Johnson & Lakoff 2011). Following the usage of Presmeg (2006), Jonson & Lakoff (2011) “a visual image is taken to be a mental construct depicting visual or spatial information, and a visualizer is a person who prefers to use visual methods when there is a choice" (Jezdimirović 2014, 282).

Bodily-kinesthetic learning types and approaches

Johnson (2011,1) suggests providing a specialized environment for "The Kinesthetic Learner". Those learners like tactility and movement, "... and learn best by interacting or experiencing things around them. They benefit from hands-on engagement, rather than listening to a lecture or reading from a book. They like to act things out and use their bodies to remember facts". She believes these learners "enjoy role playing, building, hands-on experiments, dance or physical activity, and sports". By using their physical inclinations they are enabled to remember and process better; this learner type is not particularly fond of writing and prefers group work.

During the Sumer School in Belgrade and Closing Conference, a group of teachers (Tatjana Stankovic, Ljiljana Djuretanovic, Nada Rankovic) presented one bodily-kinesthetic tool: PLATOGROUND- A GAME THAT LINKS TEACHING MATHEMATICS AND PHYSICAL EDUCATION, which was influenced by the project and developed by them over the previous months. The detailed description of this tool can be found on the web site of the project, as well as in the Closing Conference reader. But recent research work proves that we seek to emphasize attention to learning styles (visual, auditiv, kinesthetic etc.) , "for which evidence has not be found" (Riener & Willingham 2010, 35).

Motivational approaches: Enjoyment
Implementation of math related computer games, ICT

The previous studies of Lambić & Lipkovski (2011, 195) proved that the quantity of expressed positive attitude (enjoyment) of students towards mathematics is almost equal to the quality of acquired knowledge. Digital tools for visualization and interaction support understanding of the subject. They suggest to develop a greater number of software and games in mathematics because the entertainment component for students could be drastically increased (Lambić & Lipkovski (2011, 195). The findings of Afari et al. (2013) proved that the use of mathematic games enhances students' enjoyment of math classes and academic efficacy. According to Paraskeva et al. (2010, p. 499), the use of games is a "fun, engaging, motivating, interesting and encouraging way" of teaching. Games are part of most students' everyday lives but are not applied in school. The obvious gap of "school - out of school" context could be narrowed with the application of mathematic games in the school context. This attitude would also support the aforementioned need for empathy with students and pick them up where they are even and where their fields of interest lie. Furthermore, teachers should attempt to create a fun atmosphere in the classroom (Chalkiadaki 2009). Games in particular provide the possibility to adjust and control individual performance by students themselves and therefore enable intrinsic motivation (Deci 1975).

Secondary and high-school teachers need teacher training in ICT at college, undergraduate and university level and further training. They should be involved in programming math related games if possible, and receive training in math-related computer programs to improve their competencies.

Regarding teacher training, it should be emphasized that ICT training is highly recommended because teachers need to be role models (compare Hattie 2013). Jezdimirović (2014, 277) could prove that especially GeoGebra and functions of a real variable, arrays, limit function, continuity of functions, derivatives and applications of derivatives support the understanding of and interrelationships between theory and its applications in sciences. In her further investigations, Jezdimirović (2014, 278-279) found little didactic e-learning material in Serbian kindergartens, an adequate amount in primary schools and more than enough in high school and at undergraduate level. Although there exist an increasing number of teachers applying Blended Learning (BL), which is a combination of Computer Supported Collaborative Learning (CSCL), Problem Based Learning in ICT (PBL), Mobile Learning (ML), Jezdimirović stresses the lack of clear methodology to apply these approaches to general education (Frohberg et. al 2009, 307-331), which "emphasizes the need for detailed pedagogical caution in creating didactic e-materials" (Jezdimirović 2014, 277). Serbian teachers engaged in the VISMATH project worked precisely on some of these problems and designed didactic materials: (http://vismath.ektf.hu/index.php?l=en&m=311).

Jezdimirović (2014, 284) emphasizes that "The National Center for the Advancement of Education and National Center for Professional Development in Education for the last several years have been promoting and conducting many seminars and workshops that are supposed to help teachers to modernize their lessons. At the same time, for the purpose of individualization and differentiation of the teaching/learning process, numerous programs are available (for example NetSupport School)".

But it is still highly recommended to not only implement ICT courses into curriculums of teacher training at all educational levels and provide workshops on ICT, but also on game design and youth culture to understand the needs and virtual worlds of the students. Support on the part of the ministries of education should support teacher trainings and technological infrastructure at all educational establishments.

Motivation of students and teachers in secondary and tertiary level appears highly responsible for quality and engagement. We will discuss motivational aspects and influence on math education. Moreover, motivation is considered as a key dimension of attitudes (Tapia, 1996). Čičević et. al (2012) refer in their research to the considerable amount of research on the effects of attitudes toward learning on students' behaviors. Positive attitudes toward any subject are frequently found to enhance the students' interest in the subject and their motivation to learn. Successful learners are enthusiastic, exhibit confident attitudes toward learning, have positive expectations and do not experience anxiety about learning (Braten and Stromso, 2006; Duarte 2007).

There have, over the years, been many interpretations linking motivation with various psychological functions. Two current need-theories (Self-determination theory and Self-worth theory) contribute to the understanding of motivation more extensively. Deci & Ryan (1985, 2000) believe that human beings have basic needs (Deci & Ryan 2000, 9): besides health and satisfaction (Maslow 1954) they need autonomy (e.g. Deci 1975), which means to decide and initiate, rule by own conduct, social relatedness (Baumeister & Leary 1995; Baard et al 2004, 2046), which means respect and trust for collaboration and a feeling of competence (e.g. Skinner 1995), which means meeting challenges well. Furthermore, motivation depends on the importance of the social nature present in schools (Weiner 1990) and the role of the environment (Bandura 1986). If students do not feel addressed by content, they are not motivated. Since we learned from the first survey in 2013 that students miss "real-life-projects", visualized representation and hands-on objects seem to motivate students more and thus they engage with mathematics more. Research results related to attitude and motivation in education have produced similar results:

Jenkins & Nebraska (2006, 4) researched facts that influence mathematics attitudes with action research and qualitative research in specific classrooms and found "possible connections between mathematics attitudes and such things as student-teacher relationships, teaching methods, educational values held by the family and community, home environment, presence (or lack of) a positive role model, selective interest in other areas of the curriculum, a student's innate character, and/or his or her identified intelligence domains". They refer to Howard Gardner and his eight definitions of intelligence and quote another research work, using his method entitled Improving Student Motivation and Achievement in Mathematics through Teaching to the Multiple Intelligences (Bednar et al. 2002, 3). They came to the conclusion that students have an inability to transfer math concepts into real-life situations and leave the mathematical context in school.

This survey revealed similar results (from 2002) to those of our research group (VISMATH 2013/14) namely that students seem not "to develop a keen sense of the mathematics in the world around them when they complete daily activities such as shopping, watching a football game, or questioning the day's temperature". Their research led to the conclusion that there is a need for non-traditional teaching strategies via individual learning styles and that mathematics should be connected to other disciplines to facilitate insight into interrelationships between math and the world and to discover the importance of the subject. "Literature suggests that instruction needs to be real life, personalized, engaging, interdisciplinary, and multiple intelligences based" (2002, p. 3). This seems self-evident, but much research has been published which reached similar conclusions but the findings were not implemented in teacher education and lifelong learning.

Some misunderstandings might have led to this insufficient implementation:

#**Real-Life:** math books still suggest examples of real-life but do not let children try out real-life tasks. Furthermore, it is extremely rare for reference to be made to youth culture, needs and interests. Bell (2009, 289-314) describes how students want to "experience excitement, interest, and motivation to learn about phenomena in the natural and physical world". They are curious and observe their environment; everyday experiences should be allowed to be brought into the classroom. Aikenhead (1996) described the process of science education as one in which students must engage in "border crossing" from their own everyday world culture into the subculture of science. Teachers need to be encouraged to empathize with their students and build bridges between youth culture and math tasks, and to allow students to try-out haptic or virtual games in order to find questions and task solutions for themselves.

#**personalized learning and multiple intelligences based** means that students have their own ideas about, and individual approaches to learning. These should be identified either by fostering different types of learners (visual, auditory, kinesthetic or just specific interests) or using, for example, the method of Gardner: verbal-linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical-rhythmic, interpersonal, intrapersonal, naturalist (Jenkins & Nebraska 2006, 31). Dunn et al. (2003) describe a model of five dimensions: biological, emotional, sociological, physiological and psychological. Opinions differ if learning styles should be provided (Dunn et al 2003) or missing ones supplied (Apter 2001). Hartley (1977) as well as Horak (1981) came to the conclusion that individualized learning has little effect on mathematical performance in school. Waxman et al (1985) believe that individualized learning has an effect on learning but only if the students can decide what they need (Hattie 2013, 235).

But the theory of learning-styles has been shown to be a myth and cannot be proved scientifically. Riener & Willingham (2010) argue that there is no credible evidence that learning styles exist. They agree with the claim that "Learners are different from each other, these differences affect their performance, and teachers should take these differences into account" because this argument is considered as true, and recognized by educators and cognitive scientists alike. But the difference is explained in a more explicit manner, for example. "learning basic math facts is critical to the acquisition of later math skills, therefore a difference exists" (2010,33). They (2010, 34) assert "that a certain number of dimensions (ability, background knowledge, interest) vary from person to person and are known to affect learning" and they consider these facts as more important than the focus on learning styles. They (2010, 34) demonstrated that learning-styles (visual, auditory etc.), tested under controlled conditions, do not make any difference. They believe that adjusting a lesson, which takes into account students' background knowledge and interests, is an important strategy in fostering learning. Therefore development of different teaching methodologies might be relevant, but learning strategies as visual, auditory etc. are irrelevant. The application of visual mathematical tools before/after was not in the (TAS) but it was in other research (comp. Riener & Willingham 2010) and cannot be said to have made marked improvements in learning outcomes. Rather the problem of understanding individual need, ability, background knowledge and interests of the student should be targeted.

#**interdisciplinarity means** that students are encouraged to transfer knowledge from one subject to several interrelationships.

Interdisciplinarity is described by Mateus-Berr (2014, 73-116) in *Springer Encyclopedia on Creativity, Invention, Innovation and Entrepreneurship*:

> *Klein (2010, 17) considers interdisciplinarity in science disciplines as a challenge "where almost all significant growth in knowledge production occurred at the borderlines between established fields." The term discipline derives from the Latin word disciplina, is associated with pedagogy and "signifies the tools, methods, procedures, exempla, concepts and theories that account coherently for a set of objects or subjects" (Klein 1990, 104). Interdisciplinarity is considered as a synthesis of two or more disciplines,*

establishing a new method of discourse (Klein 1990, 66) with the need of disciplinary behavior, which might seem paradox (Klein 1990, 106).

Dalrymple & Miller (2006, 31) believe, that "interdisciplinarity encourages 'multilogical' thinking – the ability to think accurately and fair-mindedly within opposing points of view and contradictory frames of reference."

The misunderstanding in the case of interdisciplinarity lies within the wrong understanding and definition of interdisciplinarity: as Klein (1990, 106) stresses: disciplinary behaviour and knowledge is essential and DeWachter (1976, 53) underlines the need of translation into the language of the others.

> *"Until there is willingness to change one's mind and translate conviction into a language the other will fully appreciate, no interdisciplinary communication has taken place." (DeWachter 1976, 53).*

In school we experience interdisciplinarity more as approaches to a topic from different subjects (German: "fächerübergreifend") which as a method does not translate at all, or abuse subjects as for example arts and design for tasks: a German teacher asks an art teacher to design the stage for a play, but this is not interdisciplinary, it is more akin to an order. Of course it could be organized in an interdisciplinary way but this depends on the views and understandings of the teachers and of their capacity for "translation". Religion teachers love to use the arts for religious reflection, and math might be facilitated in understanding and in interest by arts. But arts and design are very special disciplines with long studies and personal experience. In this case art merely obtains an order and collaboration is not really the key. 'Race to the Top' inspires governments to support STEM, which emphasizes science, technology, engineering, and math over the humanities, arts and social sciences. McBrien (2014) believes that arts are important as a separate discipline of study. Arts should act as a means to explore other subjects, "through the arts". In Austria, the chamber of industry even considers creating a school "through design", where design plays a key role in the curriculum, and around which other subjects are built. Funding agencies such as the U.S. National Science Foundation (NSF) and European Science Foundation are increasingly setting research agendas to support synthesis (Gutmann, 2011; Simon & Graybill, 2010; Klein 2010). Truly interdisciplinary approaches might develop insights in the connectedness of subjects for the student. To stay with Feyerabend (2010, 132), we believe that "knowledge needs a plurality of ideas, (. . .) and that well established theories are never strong enough to terminate the existence of alternative approaches." He considered science as a confused political process, a new experience and argued "against established methods" in science. He calls into question methods of exact and systematic methods and encourages "irrational approaches" as a basis for experimental research. He believes that scientists should use artistic research. A different approach – that of an artist/designer and that one of a mathematician would facilitate different understandings and literacies. At least qualitative studies should accompany quantitative surveys, which would support insights of students', teachers' and parents' attitudes.

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Appendix

QUESTIONNAIRE for TEMPUS 2013-2014

What is your age?	________			CODE
Gender:	FEMALE		MALE	
Do you live in	City		Village	
Your mother's education is	elementary	high school	university	
If university, which one	science/math	humanities	biology/medicine	law/economics
Your father's education is	elementary	high school	university	
If university, which one	science/math	humanities	biology/medicine	law/economics

1. How often do you use mathematics in your everyday life?

A few times a day	Every week
Every day	Every month
A few times a week	Less than once a month

2. How often do your parents use mathematics in their everyday life?

A few times a day	Every week
Every day	Every month
A few times a week	Less than once a month

3. Rate the correctness of the following statements about the science of mathematics!

(1 is completely incorrect, 5 is completely correct)	**1**	**2**	**3**	**4**	**5**
Mathematics is essential for all humans					
Mathematics is difficult and hard					
Mathematics improve intelligence					
Mathematics is not important for everyday life					
Mathematics is most important course in school					
Knowing mathematics opens the door to a future career					
My parents think it is very important to know mathematics					
My parents think mathematics is important for everyday life					

4. Rate the correctness of the following statements about the mathematics education in your country!

(1 is completely incorrect, 5 is completely correct)	**1**	**2**	**3**	**4**	**5**
Most people were bored at mathematics classes					
Mathematics could be taught in a more entertaining way					
There is not enough mathematics in school					
Most teachers of mathematics are very good					
We could have learnt more mathematics if it was presented in a better way					

5. Did your education prepare you for the mathematics you usually need?

YES / NO

6. I have learnt a lot of mathematics during my education

YES / NO

7. My grade in mathematics last year was: 1 2 3 4 5

8. My average grade last year was: 2-3 3-4 4-5 5

9. I study math at home:

Less than once a week
Once a week
2-3 times a week
4-5 times a week
Every day

10. When I study math at home I do it:

About 15 minutes
Less than an hour
For about an hour
For about two hours
Longer than two hours

11. Rate how much the following statements describe you and your habits

(1 is completely incorrect, 5 is completely correct)	**1**	**2**	**3**	**4**	**5**
Mathematics was always easy for me					
Somebody always help me with my homework in mathematics					
I am happy with my mathematics grades					
The math education I received was unsatisfactory					
I wish I knew more mathematics					
I found mathematics classes to be a complete waste of time					
I wish I had paid more attention during mathematics classes					
Our classes in mathematics were boring					
My parents are happy with my mathematics grades					
My parents are happy with my mathematics knowledge					

12. Did you ever take extra mathematical classes (private or at your school)?

NO	A few times
YES	All the time

13. Rate how often your teachers of mathematics used

(1 is never, 5 is always)	**1**	**2**	**3**	**4**	**5**
Computers					
Presentations (power point for example)					
Real physical objects and models					
Computer games					
Mathematical tales, anecdotes, historical facts					
Individual games and playful activities					
Internet					
Art – painting, sculpture					
Art – music, dance					
Art – movies					
Art – situation games					
Visits to science museums/centers or art museums					
Outdoor games					
Work in groups and playful activities					

THANK YOU!

Supplementary Table (one for each class)

School name		
Year and class interviewed		

Full name - Teacher of mathematic		
Full name - School psychologist		
Full name - Interviewer		

City		
Date		
Time		

Signature of the person who filled this table		