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**Teachers' Approaches to Teaching Mathematics in the Context of Real-Life:
Mathematical Modelling in Secondary Schools of Kazakhstan**

Rassul Akhmetbekov

Submitted in partial fulfillment of the requirements for the degree of Master of Science
in Educational Leadership

Nazarbayev University Graduate School of Education

June, 2019

Word Count: 17 300

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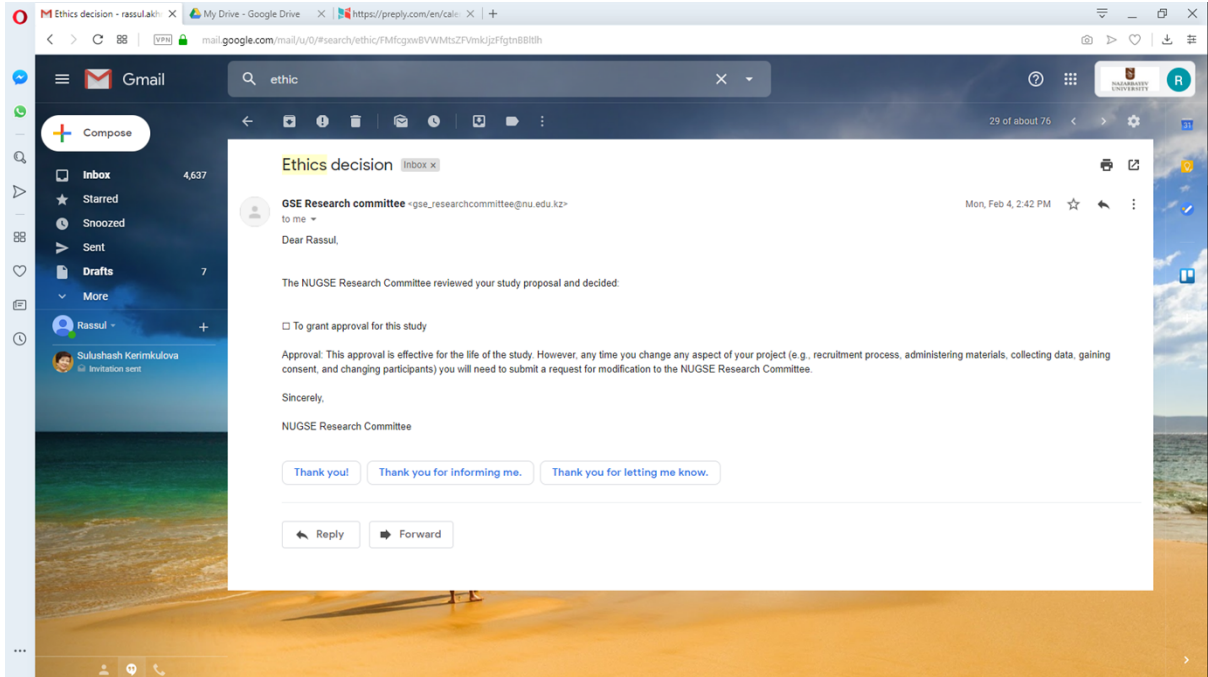
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Acknowledgment

I would like to express my deep gratitude towards my supervisor – Dr. Kathy Malone for her valuable guidance, endless support and motivation to proceed at every stage. In spite of her busy schedule Dr. Malone was always available to help me with all my doubts and queries.

In particular, I would like to thank professor Darkhan Bilyalov for teaching me how to do quantitative research using SPSS software. I also appreciate Mathematics teachers of Kazakhstan, who attended my survey for their willingness to contribute to my study and share valuable information. And of course, my dear professors of NU GSE, you are the best. Thank you for making me better. I cannot express my gratitude more deeply to my dearest wife Ainagul and son Ali who have shown endless support and patience. Their belief in me has motivated me to continue to push forward and to work hard. I am so grateful to my dearest friends Yermek, Nadya, Aidana, and Yernar who were always with me and supported me a lot. I have done this big work thanks to these guys. Many thanks to my group mates for being so smart, funny, and for being a family during these years. I would like to express my special thanks of gratitude to my friend Aligassan M. for giving me golden support and big motivation to work hard and to go forward towards my goals.

Abstract

The purpose of this study was to examine Mathematics teachers' perceptions of and knowledge about Mathematical Modelling in Kazakhstani secondary schools. Mathematical Modelling (MM) is a method to teach real life problem solving. Additionally, this study examines teachers' opinions about barriers and challenges to teaching MM as well as the necessity to teach mathematics through real-life problems. The research was conducted using the quantitative correlational research design, descriptive statistics, and t-tests.

One hundred thirty-four teachers of mathematics from different secondary schools of Kazakhstan participated in the MM survey. Demographic data (e.g., teaching experience, age, gender) about the participants was also collected on the survey. In addition, teacher knowledge about Mathematical Modelling and Real Life problems as well as their perceptions about the use of MM was assessed.

The results of the study showed that overall teachers are not familiar with Mathematical Modelling. Furthermore, teachers' who thought they knew MM, in general, did not score well on the assessment. The study shows that teachers are willing to use Mathematical Modelling, however, they believe that there are a number of obstacles and concerns. For instance, they tend to think that the lack of curriculum and textbooks on MM as well as negative student and parent perceptions would hinder their ability to implement MM. This study highlights the demand for Professional Development on MM and adequate regulations from policy-makers to implement MM.

Keywords: Mathematical Modelling, Real Life problems, secondary schools, Mathematics education, Kazakhstan

Абстракт

Целью данного исследования являлось изучение восприятия и знаний учителей математики о математическом моделировании в контексте казахстанских средних школах. Математическое моделирование (ММ) - это метод обучения проблем реальной жизни. Кроме того, в этом исследовании рассматриваются мнения учителей о препятствиях и проблемах в преподавании ММ, а также о необходимости учить математику через проблемы из реальной жизни. Исследование проводилось с использованием количественного корреляционного плана исследования, описательной статистики и t-теста.

В опросе ММ приняли участие сто тридцать четыре учителя математики из разных школ Казахстана. В ходе опроса были собраны демографические данные (например, опыт преподавания, возраст, пол) участников данного анкетирования. Кроме того, были оценены знания учителя о математическом моделировании и проблем реальной жизни, а также их представления об использовании ММ.

Результаты исследования показали, что учителя в целом не знакомы с математическим моделированием. Кроме того, учителя, которые думали, что они знают ММ, в целом, не смогли правильно ответить на вопросы о ММ. Исследование показывает, что учителя готовы использовать математическое моделирование, однако они считают, что существует ряд препятствий и проблем. Например, они склонны думать, что такие факторы как отсутствие учебных программ и учебников по ММ, либо негативное восприятие учащихся и родителей будет препятствовать их способности реализовать ММ на своих уроках. В этом исследовании подчеркивается потребность в профессиональном развитии ММ и адекватные нормативные акты со стороны политиков для реализации ММ.

Ключевые слова: математическое моделирование, проблемы реальной жизни, общеобразовательные школы, математическое образование, Казахстан\

Аңдатпа

Зерттеудің мақсаты математика мұғалімдерінің қазақстандық орта мектептегі математикалық модельдеу туралы білімі мен ұғымын зерттеу болып табылады.

Математикалық модельдеу (ММ) - бұл шынайы өмірлік мәселелерді оқыту әдісі. Бұдан басқа, бұл зерттеу мұғалімдердің ММ-дің оқытудағы кедергілері мен проблемалары туралы пікірлерін, сондай-ақ нақты мәселелер бойынша математиканы оқыту қажеттілігін қарастырады. Зерттеу сандық корреляциялық зерттеу жоспары, сипаттама статистикасы және t-тесті бойынша жүргізілді.

ММ зерттеуіне Қазақстанның әртүрлі мектептерінен математика пәнінің жүз отуз төрт оқытушысы қатысты. Зерттеу сауалнамаға қатысушылардың демографиялық деректері (мысалы, педагогикалық тәжірибе, жасы, жынысы) жиналды. Бұдан басқа, мұғалімнің математикалық модельдеу және шынайы өмірлік проблемаларды білуі, сондай-ақ ММ ұғымы туралы түсінігі бағаланды.

Зерттеу нәтижелері мұғалімдер жалпы математикалық модельмен таныс емес екенін көрсетті. Оған қоса, ММ білетін деп санайтын мұғалімдер, әдетте, ММ туралы сұрақтарға дұрыс жауап бере алмады. Зерттеу көрсеткендей, мұғалімдер математикалық модельдеуді пайдалануға дайын, бірақ олар бірқатар кедергілер мен проблемалар бар деп есептейді. Мәселен, ММ бойынша оқу жоспары мен оқулықтардың болмауы немесе оқушылар мен ата-аналардың теріс қабылдауы, олардың ММ-ді өз сабақтарында қолдануына кедергі келтіретін факторлар деп санайды. Бұл зерттеу ММ-ны жүзеге асыру үшін мұғалімдердің ММ төңірегінде кәсіби дамуын және саясаткерлердің тиісті нормативтік актілерін талап етеді.

Түйінді сөздер: математикалық модельдеу, нақты өмірлік проблемалар, жалпы білім беретін мектептер, математикалық білім, Қазақстан

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Chapter 1: Introduction

1.1. Introduction

Kazakhstan is a young country in the post-Soviet space, looking for its place on the world stage. During the years of independence since 1991, a huge number of educational reforms were carried out, which were aimed at finding the optimal form of education for the younger generation. In addition, foreign experts from OECD and World Bank were invited to more effectively create an educational system. According to them, in the country, elementary school students study mainly the theoretical part of the school subject, hence the applied part in the Kazakhstan schools requires improvement (OECD, 2014). The then President of the Republic of Kazakhstan voiced the need to improve the quality of teaching subject lessons in his speech, "It is necessary to strengthen the quality of teaching in the mathematical and natural sciences at all levels of education. This is an important condition for preparing young people for a new technological structure" (From the message of the then President of Kazakhstan January 2018). From this it follows that it is necessary to find new ways to improve the teaching of subject knowledge, which in turn led to the creation of this study. This study examines the teaching of mathematics lessons in the schools of Kazakhstan. There exists different approaches of teaching mathematics to the students, and this study aimed to consider two common approaches. The first approach is the classical approach, which involves teaching mathematics through memorizing a formula and fixing it through a huge number of tasks. Students of such approaches are very strong in theoretical part of mathematics and usually takes good prizes at Mathematical Olympiads or in similar competitions. Kazakhstani students for the most part are the results of that approach, the results of the TIMMS exams is the good evidence of that as they score well on TIMSS monitoring exams (OECD, 2014). Kazakhstani students know many formulas, and know the names of great mathematicians; however, is there any necessity of such knowledge in

students' adult life. For example, will they need trigonometry at age of 30? In my practice, students of such approach were questioning the necessity of Mathematics at all, in comparison to the second approach (Lesh, & Doer, 2003). In the second approach, students in Mathematics lessons were taught using a different principle, with a focus on application and conceptual understanding. As a result, students were having less problems understanding the necessity of Mathematics in their adult life. Because the second approach was focused more on questions about why to study, instead of what to study, which means it doesn't measure students ability to memorize, but measures students' skill to think, to analyze and to synthesize on real life problems. As a result, the following research is aimed to measure Mathematics teachers' pedagogical understanding of Real Life problems in their practice, especially their perception about Mathematical Modelling.

1.2. Background of the Study

Kazakhstan is a Post-Soviet country, who pays much attention to its educational systems. The Soviet legacy is still present in the Kazakh schools. The teaching of mathematics in schools is one example of that heritage. For instance, since the Soviet times, Mathematics lessons in middle and high schools are being taught as two different subjects, Algebra and Geometry. In the Algebra class, students learn Numbers, Functions, Trigonometry, Calculus, Statistics, Probability and Algebra. In Geometry class, students study Planimetry, Stereometry and Vectors. Many famous mathematicians of the twentieth century were from the Soviet Union, therefore mathematics in the Soviet Union was taught at a very high level. The result of this heritage is the results of the Trends in Mathematics and Science Study (TIMSS) (Ruby & McLaughlin, 2018). TIMSS is an international association for the evaluation of educational achievements in mathematics and natural sciences among pupils of the 4th and 8th grades. According to the results of this exam, students of Kazakhstan perform well (Gonzales, Williams, Joeklyn, Roey, Kastberg, &

Brenwald, 2008, p. 17). However, according to the results of another exam called the Program for International Student Assessment (PISA), students showed weak results, because PISA exams are more focused on the ability of students to apply Mathematics to real life problems (Bloem, 2013). Experts of TIMSS and PISA both in their report wrote, that in mathematics the exams are aimed at assessing the students' ability to apply the acquired knowledge, hence the students of Kazakhstani schools are strong in the knowledge of mathematics, but are weak in its application (OECD, 2014). According to these experts, students are very familiar with the theoretical part of mathematics, thus they know by heart all the formulas and can solve similar problems, but unfortunately, they have problems with solving higher-level problems, as well as application tasks (OECD, 2014).

1.3. Statement of the Problem

In this research, the focus will be on Mathematics teachers' perceptions about their approaches towards teaching the subject. Specifically, I will consider and assess about their ability to work with real-life problems and ability to teach Mathematical Modelling in the Mathematics lessons. A survey will be used to determine their perceptions about the use of real-life situational problems and Mathematical Modelling.

Of course, the concept of "Mathematical problems of real life" is too broad, and does not have a specific definition in this context. For this reason, at the end of the twentieth century, the concept as Mathematical Modelling was created. According to Lesh and Doer (2003) Mathematical Modelling is a process of mathematization, interpretation, verification, revision and generalization of real situations or complex systems. For example, if we talk about questions on determining the average speed of any transport using the formula $s = v \times t$ (there are many such examples in Kazakhstani Mathematics textbooks), this example will not be a matter of Mathematical Modelling. Because in this example the student uses the skill to correctly substitute the formula, but does not generally use the whole process of MM.

For instance, asking student to find out the best road from his house to school, which will save time and money could be a problem of MM. It makes students to think critically, therefore students who are taught by Mathematical Modelling are more prepared for real life, they learn quick and conceptually, they know how to develop strong argumentative points to support their thoughts, and they know how to reflect on different processes (Lesh, Young, & Fennewald, 2010). In the literature review chapter Mathematical Modelling will be discussed in greater detail

1.4. Purpose of the Study

I studied teachers' perception of Mathematical Modelling in order to understand how teachers, understand the notion of teaching Mathematics using real life problems. Especially this research will be good handbook for Mathematics teachers and policy makers. There is very little data on Mathematical Modelling in the context of Kazakhstan. A literature search only revealed two articles that indirectly dealt with this topic; therefore, policy makers may benefit from this research.

My hypothesis is that a very small number of mathematics teachers know how to teach real life problems or Mathematical Modelling in their class. For instance, one of the main tasks of the Kazakhstani secondary school Mathematics curriculum for 10-11 grades is the ability to apply mathematics in real life (NEA of Altynsaryn, 2013). Unfortunately, in the content of the current curriculum I could not find any words such as "real life", "application", or "Mathematical Modelling". Mathematics textbooks show a similar picture. For this reason, I decided to take the first steps towards understanding secondary teachers' perceptions about Mathematical Modelling. Namely, this study focused on determining what teachers know about Mathematical Modelling and how they use real life examples in their classroom.

1.5. Research Questions

The main research question and the sub-questions that will guide this study are:

What are the perceptions of mathematics teachers about using real life situational problems, such as Mathematical Modelling in their classes? Specifically,

- How do mathematics teachers understand real-life situational problems such as Mathematical Modelling?
- What are teacher perceptions concerning the need to teach mathematics using authentic problems such as Mathematical Modelling, within their classes?

1.6. Definition of the central phenomena (or terms as needed)

The key terms of this study are following: Mathematical Modelling in Secondary school. According to Lesh and Doer (2003) "In general, Mathematical Modelling is the process of mathematizing, interpreting, verifying, revising and generalizing real-life situations or complex systems."

1.7. Significance of the Study

The concept of Mathematical Modelling is relatively new in the field of school education. In addition, I could find only a few articles related to the use of Mathematical Modelling by teachers in Kazakhstan, (Balykbayev, & Aldibaeyva, 2011; Sadvakasova, 2015). These articles only included recommendations to use MM on the lessons. Consequently, the following research will paint the picture of teachers' use of real life problems in Mathematics lesson, therefore may benefit policy-makers to create better Mathematics curricula. For instance, in the State Development Plan of 2020 of Republic of Kazakhstan (Ministry of Kazakhstan, 2010) it was considered about the necessity of implementation of real life problems in secondary school subjects. In this current 2019 year, using the following study policy makers will have the opportunity to see the results of that plan. Finally, this work will familiarize some teachers of Kazakhstan with this unusual approach of teaching Mathematics, specifically it will help them to understand Mathematical Modelling.

1.8. Organization of the study

This work consists of six chapters. The literature review chapter contains a detailed definition of the basic terms of the study, as well as the practice and experience of international countries in applying Mathematical Modelling on mathematics lessons of secondary schools. Moreover, it will determine the differences in the teaching of mathematics in different countries, particularly in Kazakhstan. In the Methodology chapter, the research design, data collection and ethics of the research will be described. In this case, the study will be conducted using a survey developed for teachers of mathematics. The collected data will be analyzed by quantitative research methods. The following chapters will be called findings and discussion. In these chapters you will find the analysis of the survey targeted at answering the research questions. The discussion of the results chapter will compare the findings with analogical cases of other countries. And at the very end of the thesis, the conclusion chapter will summarize the study and develop the final conclusions along with a discussion of the limitations of the thesis, as well as recommendations for further research and for stakeholders.

Chapter 2 Literature Review

2.1. Introduction

The following chapter explains the relevant literature on Mathematical Modelling (MM) in the secondary schools. This chapter consists of three main sections. In the first section there is an overview of the definitions and concepts of Mathematical Modelling. The second section explains the educational background of Kazakhstan concerning Mathematical Modelling. Specifically the shadow of RLP in the assessments, curriculum, textbooks and professional development. The next section presents the literature on the impact of MM on educational institutions and stakeholders. The final section discusses about the perception of Mathematics teachers regarding Mathematical Modelling.

2.2. Definition of Mathematical Modelling

Researchers are only now making the first steps on implementing Mathematical Modelling in secondary schools, because the concept of Mathematical Modelling is a relatively new concept in pedagogy (Lesh, & Fennewald, 2013). Therefore, there are not any materials or methodological manuals on how to do Mathematical Modelling in Kazakhstani secondary school classes or curriculum. However, the curriculum does stress the need to use real-life problems without supplying the necessary examples for teachers to apply this in their classrooms. Sadvakasova (2015) suggests that Mathematical Modelling should be included in Kazakhstani schools in order to prepare students' 21st century mathematical skills.

In Mathematics, model's symbolize, explain, describe, or predict natural phenomena and situations (Van Den Heuvel-Panhuizen, 2003). In pedagogy, particularly in secondary schools Mathematical Modelling has it is own definition and laws. Mathematical Modelling is one of the tools to branch out from the classical method of teaching Mathematics. It is the method which allows the teaching of students to catch the fish, instead of giving them ready fish (Galbraith et al, 2010). There exists a lot of different interpretations of Mathematical

Modelling for secondary school teachers. One of the definitions is: "In general, Mathematical Modelling is the process of mathematizing, interpreting, verifying, revising and generalizing real-life situations or complex systems (Lesh & Doerr, 2003; Lingefjård, 2002)." Thus, modelling is an explanation of a real-life situation through the equation, graphs, and mathematical constructions. Blum and Ferri on their study (2009) created the cycle or framework of Mathematical Modelling (see Figure 1). According to researchers, Mathematical Modelling consist of two objects, Real life and Mathematics. Those objects are totally different concepts. Students' in the beginning, should start in left region of the cycle (see Figure 1.), which is represented as real life. Students should identify the problem or situation taken from real life, in other words "construct" the problem. Under real life, it meant existing life, nature, society, the life that is happening around the student, and his experience in everyday life. Next step for the student is to "simplify" the problem, which means the student should take only necessary elements, which can be counted, or used to do mathematics. After identifying the problem, student should move to the right object (Mathematics area) on the cycle (see Figure 1), and should work mathematically, which will require him to use appropriate Mathematical tools. After finding the results, the student should report his findings using appropriate mathematical language. The following step is to check his results for "validity" in the context of real life (on the left region of the cycle). Finally, if his results match up with the problem, then it is ok. If not, then student must start the process again.

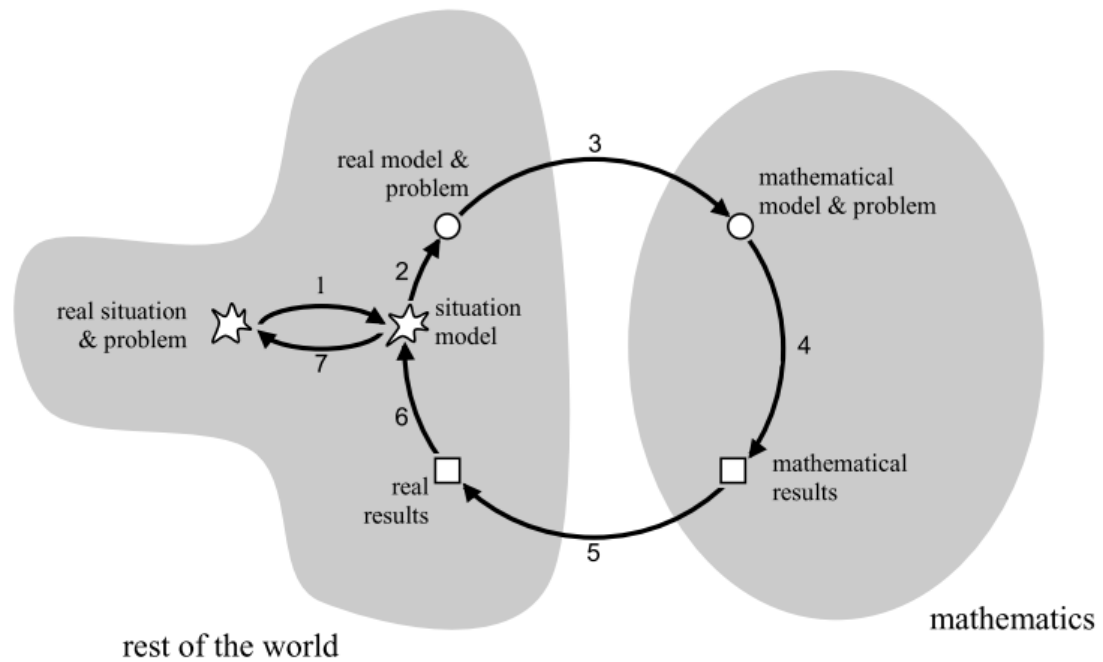


Figure 1. The Cycle of Mathematical Modelling (Blum, & Ferri, 2009).

As seen, the process of solving questions is not easy. Both teachers and students struggle a lot with the cycle shown in figure 1 (Blum, & Ferri, 2009). For instance, the following question is taken from PISA exam:

“In the sports center in the Philippines, Mr. Florentino Anonuevo Junior polishes a pair of shoes. Shoes, according to the Guinness Book of Records, the largest in the world, with a width of 2.37 m and a length of 5.29 m. Approximately how tall could there be for these shoes? Explain your decision” (See Figure 2; Blum, & Ferri, 2009, p. 47).

The most difficult part for students when solving this question is that they in general have a problem with “constructing” the problem or figuring out the question. Students in this example must create their own numbers and data, which is not what is done during their usual lessons in a traditional mathematics classroom. Next, they should “simplify” the problem, which means student must choose the right strategy to solve their problem. Once they solve the problem the final step would be the checking for “validity” step, which is often ignored by students, although according to MM it plays an important role in the cycle (Blum, & Ferri,

2009).



Figure 2. World the biggest pair of shoes (Blum, & Ferri, 2009, p. 47).

As is seen from the previous example Mathematical Modelling requires reading, communication, critical thinking and design (Niss, 2003). Therefore, teachers require more than just giving a formula and a lot of questions for drilling practice to their students.

2.3. Mathematical Modelling in context of Kazakhstan

Kazakhstan is a member of both the Trends in Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA). Following examinations are aimed to evaluate the educational knowledge of secondary school students of different countries, and can be used as an indicator for statistical analysis. TIMSS is an international association for the evaluation of educational achievements in mathematics and natural sciences among pupils of the 4th and 8th grades. Mathematics in TIMSS examination mainly checks the fundamental understanding of Mathematics, and is not focused on applications and real life problems. According to the results of this exam, students of

Kazakhstan show good results in Mathematics (Gonzales et al, 2008, p. 17). However, according to the results of PISA, secondary school students do not produce strong results (Bloem, 2013). PISA examination checks students' ability to apply their Mathematical knowledge. Moreover, Mathematical Modelling is the main focus of PISA examinations (Blum, Galbraith, Henn, & Niss, 2007). Experts of TIMSS and PISA both in their reports wrote, that in mathematics the exams are aimed to assess the students' ability to apply the acquired knowledge, hence the students of Kazakhstani schools are strong in the knowledge of mathematics, but are weak in its application (OECD, 2014). Students are drilled to solve typical questions many times, however, they are lacking with solving the high ordered questions (unfamiliar questions), as well as application tasks (OECD, 2014). In the document "State Program for the Development of Education 2016-2019" (2016) it is written that Kazakhstan's students on the PISA exam in mathematics fall 1.5 years behind their peers in other OECD countries. In order to determine the cause of this problem, one needs to consider some of the key factors directly influencing this result. It seems, that there are a lot of issues requires to be solved. According to the Development of Strategic Directions of Education Reforms in Kazakhstan for 2015-2020 document "Curriculum, assessment, textbooks, pedagogy, teacher training and school leadership all have to be developed together in a coordinated way with careful synchronisation" (Sagintayeva et al., 2014). Therefore we are going to discuss about the assessment, textbook, curriculum and PD in the further subsections.

2.3.1. Assessments and Unified National Test

The simple multiple-choice format of the Unified National Test (UNT) and Early Environmental Evaluation Assessment (EEEA) is well suited to "knowledge" questions, but they do not feature the comprehension, application or analysis questions which students

should also be asked if their higher-ordered skills and university potential are to be properly assessed" (OECD, 2014).

In Kazakhstan's secondary school educational system, there are three main state examinations for all students of secondary school of Kazakhstan and all of them include Mathematics (Winter, Rimini, Soltanbekova, & Tynybayva, 2014, p. 135). The first examination is taken when student move from primary school to the middle school. The second examination is from middle school to high school. Finally, the third examination called UNT occurs at the end of high school. Based on the results of the UNT, students become admitted to Universities of Kazakhstan. All these examinations are controlling the students' ability to solve pure Mathematical problems. The main goal for teachers is to prepare students for these final mathematics exams, which mainly consist of theoretical questions on the mathematics topics of the curriculum. Therefore, teachers are teaching mathematics through memorizing formulas and solving the large number of examples. Fimiyyar (2014, p. 189) mentioned that in Kazakhstan teachers mostly teach students by drilling them using large numbers of questions during mathematics lessons.

In the document "State Program for the Development of Education 2016-2020" (MoES, 2016) it is determined that the UNT does not evaluate the abilities and skills of a modern student, moreover it is not a valid assessment, because students only need to memorize the answers to achieve good results. Therefore, in the current rapidly changing world the UNT format used needs to be changed to a more efficient and modern thinking format. Therefore, the Ministry of Education in 2017 decided to change the format of graduation exams. In the past, students had to solve 30 questions on mathematics, now the mathematics part of the UNT exam was divided into two parts (MoES, 2016). The first part of the UNT is mandatory part. The emphasis of this part in the conceptual understanding of the subject, mainly mathematical thinking and logic. The second part is called "profilnyi", those who are willing

to become engineers or to work on STEM professions take this section of the exam. The questions in second part are more complicated and focused on knowing the pure Mathematics, similar to the old version. In the current time there is no information related to the effectiveness of the new UNT format. Nevertheless, this test change could be a great breakthrough for teaching mathematics in Kazakhstan. Teachers can now reflect on the fact that it is not necessary to train students through drilling hundreds of questions. Thus, there is a need to create new approaches and methods for teaching mathematics in order to prepare students for the 21st century. These methods would be in alignment with the Kazakhstan secondary curriculum guidelines in the State Development Plan of 2020 of Republic of Kazakhstan (Ministry of Kazakhstan, 2010) that stress the use of applied mathematics. Research by Blomhoj and Kjeldsen (2007) supports the idea that, one of the ways to teach conceptual understanding of mathematics is learning through application of mathematics, especially through Mathematical Modelling. The Kazakhstani policy-makers understand the importance of reforms in education, in particular, the change of the educational curriculum towards an applied one (Shamshiddinova, Ayubayeva & Bridges, 2014, p.75). In my work, I want to understand teachers' perceptions and understanding of the use of real life situational problems and Mathematical Modelling in mathematics lesson.

2.3.2. Curriculum

“While Kazakhstan boasts a 99% literacy and school enrolment rate, there were concerns about the low quality of students' knowledge and skills and, as a result, a low demand for graduates from Kazakhstani schools on the labor market” (ADB 2004; Tasbulatova, & Belosludtseva 2007, p.8).

In 2010 government approved the document called “State Program of Education Development for 2011-2020”. The main aim of that document was: “By 2020, Kazakhstan will have become an educated country with a smart economy and a highly qualified labor

force" (MoES, 2010). According to document, improvement of secondary school should be done by Nazarbayev Intellectual Schools (NIS), so the mission of that school is to be the prism of the modern educational system. As a result of that improvement is a new curriculum, which will combine Kazakhstani traditions and the best world practices (MoES, 2010).

Last time the curriculum of Kazakhstan was renewed was in 2013 and 2017. Under Kazakhstan law, all schools in Kazakhstan are required to follow this program. The curriculum of 2017 is being implemented in the current time, therefore there is no results or research analysis completed, and as a result this study will mention only the curriculum of 2013.

One of the tasks of the mathematics program (curriculum of 2013) from 7th to 11th grades is to prepare students for real-life problems, but unfortunately the topics of the sections in the mathematics curriculum are lacking words such as "real life" and "Mathematical Modelling" (NAE Altynsarin, 2013). Moreover, the topic of statistics, which is used in MM problem solving, is only a collection of formulas and data. The current curriculum is more focused on "What to teach", not on "How to teach" or "How to learn", therefore it is difficult for teachers to implement new ideas into old approaches and system (Yakavets, & Dzhardina, 2014, p. 37). Moreover, curriculum which is focused on "What to teach" causes the students to struggle as well. The curriculum based on theory becomes more difficult for students because it includes a lot of topics. Subsequently, this curriculum packed with topics is very difficult for students, who are very weak on academic subjects, therefore their whole school time may well be spent on academic theoretical seatwork which could be difficult for them (Yakavets, & Dzhardina, 2014, p. 28).

2.3.3. Textbooks

“..., textbooks and other study aids still need to be improved. The review team recorded students' complaints about textbooks that were too old and too “monochrome”, with few charts, pictures, diagrams and illustrations.” (OECD, 2014)

In Kazakhstan there are approximately five publishers publishing textbooks on mathematics. Unfortunately, I could not find any data on the quality of these textbooks, but according to the organization OECD (2014), the textbooks require further improvement. If we look at textbooks on mathematics in the context of real life applications, we can see that the examples in textbooks are aimed to check the students' ability to solve problems mechanically (Shynybekov, 2006). Of course, you can see some topics in the textbooks, which imply questions that are contained in that chapter that are based on real life situations. For instance, some questions from real life in these textbooks are questions on functions, transfusion, movement and interest, but these questions do not ask students to analysis and synthesis data, or interpret and reflect upon the results. Mostly, the questions, require students to transfer the problem into mathematical language, and then solve it. In other words, it's like hiding mathematics inside of the text. In Kazakhstan, those types of questions are called word problems. These questions do not quite fit the definition of Mathematical Modelling.

According to Sadvakasova (2015), textbooks on mathematics should include basic knowledge, which will develop necessary mathematical knowledge, and will be used in the life of students. The other part of textbooks should be focused on the application of mathematics, such as Mathematical Modelling. The policy makers of Kazakhstan agree that textbooks should be improved, otherwise, teachers are the only source to implement the real life problems in the classes. However, the problem arises from the fact that in general, teachers of public schools are not taught to solve problems from real life (Yakavets, & Dzhardina, 2014, p. 44), therefore the application of Mathematical Modelling may not be

taught in schools? Thus, there is a probably a large necessity for professional training concerning real life problems and Mathematical Modelling.

2.3.4. Professional Developments

“It will be necessary to revise the approaches to teaching and improving the qualifications of teachers. At the country's universities, it is necessary to develop pedagogical departments and faculties. It is necessary to strengthen the quality of teaching mathematical and natural sciences at all levels of education. This is an important condition for preparing young people for a new technological order.” (Nazarbayev, 2018)

Professional Development plays a crucial role in the development of Mathematical Modelling in the secondary schools. However, training on MM should not be only an explanation of strategies and methods. PD on MM requires complex involvement of teachers in the process of teaching MM (Lawrence and Gaston, 2015). That suggest that in the trainings teachers should be required to create their own problems, which will include the cycle of MM. The next course should be on teaching how to organize the MM lesson. It means teachers should learn how to plan for efficient MM lessons. Teachers need to learn how to make the lessons students centered. Moreover, knowing Information and Communication Technology (ICT) plays an important role in doing efficient MM lesson in the class. Finally, teachers need to learn how to assess the MM problems. Creating and assessing rubrics, descriptors and criteria are the elements, which are the skills that are required to be taught to teachers learning to teach using MM.

There is a lack of systematic professional development in the subject areas, which would improve teachers' professional learning and development in their whole professional lifetime (Ayubayeva, et al., 2013). In addition, there is a lack of clear standards which helps teachers in their career, as a result there is a big necessity for systematic solutions regarding PD (Ayubayeva, et al., 2013).

2.4. Impact of Mathematical Modelling on educational stakeholders

“Mathematical models and modelling are everywhere around us, often in connection with powerful technological tools. Preparing for responsible citizenship and for participation in societal developments presupposes modelling competency” (Blum, 2011, p. 19).

The introduction of Mathematical Modelling into the process of teaching mathematics is a very complex process that requires changes in teaching pedagogy. There are few studies linking the impact of Mathematical Modelling to educational impacts on students. According to one such study the results of Blum & Ferri (2009), students taught using Mathematical Modelling, felt independent and understood the topic deeper than when using a traditional approach. Students stated that they felt free to do anything they want regarding the solving of an MM task, and the teachers were not stopping their process, they were only guiding them; therefore, the lessons were easy and productive.

Chinese researchers have done research on the skills of Mathematical Modelling among pupils of Chinese schools (Fu & Xie 2013, p. 167). According to the results of this study, students with good Mathematical Modelling skills have a positive significant correlation with innovative thinking, but weak correlations with mathematics grades that assess only knowledge in mathematics. From this we can conclude that the traditional assessment in mathematics does not show a clear assimilation of skills.

According to Sadvakasova (2015), one of the reasons for the students' poor results on the PISA exams is the inability of teachers to work in a new way. Under the new concepts, students will not need trigonometry or logarithms in real life, but they need skills that they can learn through the study of mathematics. For example, the ability to calculate the required area with the available materials is much more useful than having students memorize the natural logarithm. Both of these studies suggest that as students become better at

Mathematical Modelling they will decline in their results on TIMMS which tests more factual knowledge but increase their results on assessments such as PISA.

Unfortunately, according to OECD (2014), two-thirds of educators feel that they have insufficient skills for teaching. It is very difficult to draw conclusions from these results, as it is not clear which skills the teachers lack. But if we compare the results of PISA exams and OECD data, we can assume the hypothesis that teachers, among other things, have problems with teaching mathematics in real life. In the next section the meaning and effectiveness of mathematics in real life such as Mathematical Modelling and statistics will be discussed.

2.5. Understanding of Mathematical Modelling by Teachers

There are also limited empirical research studies that have been completed that focused on teachers understanding and perceptions of MM. Galbraith & Stillman (2006), found that studying Mathematical Modelling was difficult for teachers and students due to following reasons: a) hard to identify the right process; b) complexity of teaching; and c) MM is learning about situations, for which pure theoretical mathematics is only a part. Ferri (2013), found in a survey of teachers from six different countries that they possessed negative beliefs about mathematics. According to the survey, teachers were aware of the application of Mathematics, however they were negative towards modelling questions, because they thought, that their use in the classroom required a lot of time and were too difficult for their students. The research of Bautista, Wikerson-Jerde, Tobin & Brizuela (2014) showed that teachers in the US have vastly different knowledge about Mathematical Modelling. Specifically, they had differences in terms of terminologies, strategies, beliefs and ideas. According to SIAM reports (2014), the majority of teachers wrongly believed that MM could involve unrealistic scenarios such as pattern blocks or tangrams, which means they thought that MM was about constructing different objects and shapes using geometrical shapes made of paper. As a result, all of the researchers above, claim, that the role of

Professional Development is crucial to improve teachers' level of knowledge about MM as it seems to be seriously lacking in a number of contexts

Overall in context of Kazakhstan, the most of literature reviews concerning Kazakhstan and Mathematical Modelling talks about necessity to implement MM in the secondary school, however, does not talk about the methods or recommendation to implement the MM. Moreover, the authors which used word MM in their articles, did not concern about the cycle of Mathematical Modelling. Other articles were only mentioning about application of Mathematics, but with no specific strategies. However, the articles of OECD countries, were concerning about the problems and recommendations of using MM, therefore, there is a gap between the articles of Kazakhstan and OECD.

2.6. Conclusion

In summary, this chapter included the literature of Kazakhstani and international experts and policy makers. The state documents of education of Kazakhstan, calls for changing the curriculum of subject lessons to more of an application approach. However, local researchers say that curriculum and teachers are not intended for teaching applications in the secondary schools. As a result, OECD reports (2014) found that students have the ability to solve theoretical questions on Mathematics, but not application questions.

One of the methods to implement applications in the class is Mathematical Modelling (Blum, & Ferri, 2009). It allows students to be prepared for adult life, and makes them skillful. Teaching MM consists of the cycle of MM, which includes simplification, transfer, working mathematically, reporting and justification of the results. In addition, Mathematical Modelling was shown to be the main focus of PISA examination questions. However, Kazakhstan is below average on the PISA examination. International experts claim, that to implement Mathematical Modelling in secondary school, it can be a complex approach.

However, most attention should be paid to high qualified Professional Development to facilitate the transitions.

The past research and the modeling framework or cycle will guide this study since in order to accomplish the goals of the country's mathematics curriculum there is a need to learn if Kazakhstani math teachers not only understand modelling but what their perceptions are about it. Following study going to show, that Kazakhstani teachers of Mathematics are not familiar with Mathematical Modelling, therefore, there is a need for further implementation of it. This information would be needed to develop policies and PD to facilitate high quality math education in Kazakh secondary schools. Therefore, the next chapter will discuss the methodology that will be used to accomplish this goal.

Chapter 3 Methodology

3.1. Introduction

This chapter discusses and justifies the methodology used in conducting this study. The purpose of this chapter is to explain the research design used, as well as the procedures that were necessary for data collection. In the case of this study, this chapter considers how the survey was conducted, how mathematics teachers were recruited for the study, as well as about the techniques used to analyze the data. At the end of the chapter, the ethical side of this study is considered.

The purpose of the study is to determine mathematics teachers' perceptions and knowledge about Mathematical Modelling, real life problem solving as well as the use of statistics and data in the context of secondary mathematics classrooms.

The main research question and the sub-questions that guided this study are:

What are the perceptions of mathematics teachers about using real life situational problems, such as Mathematical Modelling in their classes? Specifically,

- How do mathematics teachers understand real-life situational problems such as Mathematical Modelling?
- What are teacher perceptions concerning the need to teach mathematics using authentic problems such as Mathematical Modelling, within their classes?

3.2. Research Design and Rationale

This study aims to identify Mathematics teachers' perceptions and knowledge about real life problems and Mathematical Modelling; therefore, this study focused on Mathematics teachers. The hypothesis of this research is that teachers' are not familiar with nor are they knowledgeable about Mathematical Modelling, therefore they could not teach their students how to apply Mathematics in their real-life. This hypothesis requires the use of quantifiable data in order to determine teachers' knowledge about MM. In addition, factors or variables

that affect their knowledge can be explored. Therefore, a quantitative research method is more appropriate to reject or to accept a hypothesis, therefore it includes non-experimental design such as survey research, which will give opportunity to see how one variable impacts other variables (Cresswell, 2014).

This quantitative study made use of a survey. There were two versions of the survey: an electronic questionnaire and a paper questionnaire. Both versions were identical. The survey was prepared using "Qualtrics" software. Qualtrics software is a platform which allows for the collection of data via online surveys and gives opportunity to immediately deliver the results (Martin, 2013). This allowed the research site to be open as teachers could take it wherever they choose.

One of the tasks of the State Program of education and science development in the Republic of Kazakhstan (MoES, 2016) is to develop the curriculum, which will be focused on applying the subject knowledge. The OECD report (2014) claimed that students of Kazakhstan in general are strong in theoretical part of Mathematics, however, are weak in applying the Mathematical tools in real-life problem questions.

As a result, the following research is designed to assess, if teachers' of Kazakhstan are familiar with Mathematical Modelling, therefore they are not able to teach, how to solve modelling questions which are the focus of the PISA exam (Blum, et al, 2007). If this study's hypothesis is proven true via the use of quantitative methodology than this study will highlight the need for changes in the Kazakhstani educational system as well as its professional development programs in order to achieve the goals of the Ministry of Education and Science. Therefore, since there is a lack of empirical research concerning Mathematical Modelling in the context of Kazakhstan and elsewhere this study will fill a gap and should allow specifically for an exploration of how to improve Kazakh students' mathematical

application skills. If hypothesis is not proven, then it will require the use of qualitative research in order to see the more detailed opinions of teachers on MM.

3.3. Research Site

230 in-service teachers of Kazakhstan took the survey. The majority of survey responses were collected from the electronic survey. Due to the fact, in Kazakhstan there are special groups of Mathematics teachers on social messaging sites, the link to the survey was posted on these messaging sites. The posting reached mathematics teachers across Kazakhstan that were teaching in a various types of schools. Only teachers of one school was able to use a paper-based survey, due to the fact the vice-principle of that school gave permission for its use.

3.4. Sample and sampling procedures

The majority of sample of the research were created using online survey. The link of the survey was shared using an online messenger, where 6000 Mathematics teachers from different regions of Kazakhstan are members. According to the sample, at least one participant from each region of Kazakhstan took the survey. Moreover, the sampling shows, that the participants of the survey are the teachers of different school categories. Most of the teachers are from mainstream schools, due to the fact mainstream schools are the majority. For a more detailed sample demographics from the survey participants see Figure 3 and Figure 4.

3.5. Data Collection Instrument

As it was mentioned before, the surveys were provided using "Qualtrics" software, and distributed using online messengers and paper-based survey. "Qualtrics" software, allows participants to respond survey without any need of authorization from school gatekeepers. Teachers only by pressing the link may start the survey. The survey was provided in three languages, due to the fact Kazakhstan have two formal languages, Russian and Kazakh, and

English language is for the analysis. Language teachers from the authors' working school checked the translation of the surveys for control of lost in meaning. Science teachers from authors' working school checked for reliability and validity of the surveys. There was also a small pilot group that checked the online survey flow in different languages.

The first page of the survey included the consent form, where participants were required to consent to the use of their respond results during data analysis and reported. If they did not give consent they were not allowed to continue taking the survey. Next, they were asked about being a teacher of Mathematics. If the participant were not a teacher of Mathematics, they were automatically moved to last page of survey, which included appreciation words. The second part of the survey consisted of the questions related to the research questions. This part consisted of several sub-parts. In the first sub-part of the survey, there were general questions regarding gender, age, teaching experience, education, location, and professional development. This part required was used to check the results of data sampling against the demographics of Kazakhstan. The second sub-part consisted of questions about the basic concepts of Mathematical Modelling, that is, the basic concepts of how they understand real life scenarios in mathematical problems. They were directly asked about being familiar with Real life problems or Mathematical Modelling. The third sub-part was directly related to the teachers understanding and knowledge of Mathematical Modelling. For example, there was one question from the PISA exam concerning Mathematical Modelling, and participants were asked to decide if the question was an example of a Mathematical Modelling or not. A sample of this question is:

***Do you think, this is a MM question?:** Jean assumes the colony will continue to grow in the following manner:*

- *At the beginning of each year, the colony consists of equal numbers of male and female penguins who form couples.*

- *Each penguin couple raises one chick in the spring of each year.*
- *By the end of each year 20% of all the penguins (adults and chicks) will die.*
- *One year old penguins will also raise chicks.*

Based on the above assumptions, which of the following formulae describes the total number of penguins, P , after 7 years?

The fourth part of survey asked about teachers' attendance at professional developments on MM or RLP. The fifth part of the survey asks about their concerns of teaching using MM. For instance, they were asked questions about their opinion about the benefits of teaching with this new approach and what was the condition in their schools that would allow or not allow for the implementation of MM. Finally, in the end of the survey, participants were asked for their phone number for further contacting in order to participate in a lottery. The survey was adapted from one developed in the US context (Groshong, 2018).

The survey can be seen in Appendix A

3.6. Data Collection Procedures

For distribution of the questionnaire, WhatsApp and Telegram messenger were used to distribute the electronic questionnaire. In Kazakhstan there are several WhatsApp and Telegram groups for mathematicians of Kazakhstan, which gave the opportunity to reach the audience the author need to take the research survey. Those messengers gave the opportunity to collect 220 responses of survey and an additional 10 responses were achieved by the paper-based survey. The survey was provided in one of the three languages: Kazakh, Russian or English. According to the information-analytical center, there are about 20,000 teachers (nd) of mathematics in Kazakhstani secondary educational schools, which means that 1% of teachers took this survey.

Collecting paper-based data from public schools was problematic, due to the fact administration of schools were not open to allowing the distribution of the survey in their

schools. Therefore, paper based research mostly was not provided in public schools. The vice principle of one school was acquainted with the author of this research, therefore this survey was provided by the vice-principle to their mathematics teachers. After the completion of survey by Mathematics teachers, it was collected back from the vice-principle. Both electronic and paper based surveys notified all the stakeholders about the ethics during the research. Since the design is a survey, the teachers did not feel any stress about taking the survey, due to the fact they could take the survey at their work site or at other locations such as coffee shops and their homes. For further motivation to fill out this survey, respondents were informed about a special lottery after completing the survey. The survey respondents, who are willing to participate in the lottery, left their contact information. The raffle was for a certificate from the electronic shop "Techno Dom" for 10000 tenges.

After receiving ethics approval in November, data collection was started in February. The end of data collection of the last week of March. The result of a raffle will be conducted at the end of July, via YouTube channel and Instagram.

3.7. Data Analysis Methods

The results taken from "Qualtrics" program were downloaded to an SPSS file, therefore SPSS software was used for further analysis. The data in "Qualtrics" was collected in three different languages, therefore all the data was split into one dataset using SPSS software.

The first part of the survey was related to demographics of the participants. All the information for this section was analyzed using descriptive statistics, such as bar charts and tables. The analysis of demographics will allow the researcher to compare the data with the demographics of the mathematics population of Kazakhstan.

The second analysis of the study was aimed at checking the hypothesis regarding teachers' familiarity with and knowledge of with MM. This section's analysis made use of

Persons' r correlation coefficient, statistical t -test to check for reliability and significance as well as descriptive analysis of the answers.

The analysis regarding PD of teachers was analyzed using the "reliability analysis" tool of SPSS, which allows to compare the correlation of the teachers responds. In addition, the relation between PD on MM and teachers' familiarity with MM were checked for relationship using Chi-Square test. The "cross-tabulation" tool of SPSS tool gave the opportunity to check the teacher's responds by schools.

3.8. Ethical Concerns and Risks of Research

All ethical standards and principles required in the implementation of the survey, interviews and the research, in general, were observed. Survey results were held anonymous. However, volunteer contact information was collected in case participants wished to participate in the raffle. However, names or contact numbers were known only to the researcher. In addition, the names will not be associated with the final survey data or with the information held for the raffle. All the information about respondents including names and contact numbers for both the raffle will be hidden in a special flash card secured by a password. Qualtrics program has a security firewall, moreover all the information is being secured by Nazarbayev University (NU) agents, therefore all the names and data are in most likely safe from breaks in confidentiality. NU agents are the staff of NU team, whose role is to support the internet firewall of NU. Paper-based surveys will be collected personally by the researcher with consent form on the first page. The day after collection of the paper-based survey, they were given special number and then converted into electronic ones using an electronic database within one week. Later, the paper copies were burned. Before they are destroyed the surveys were stored in a locked file cabinet for which on the researcher had the key.

The benefits which may reasonably be expected to result from this study include determining how real life mathematical problem solving is being used in classrooms to support mathematics teachers as well as to help policy makers to create more productive professional development strategies. If the participants felt uncomfortable completing the survey they could stop taking it at any time.

3.9. Limitations

The limitation of this study was, that the survey did not include the demographics concerning rural and urban areas. As a result, we cannot compare the teachers of urban areas with the teachers of rural areas. The needs of rural area teachers could be quite different from the urban areas since urban teachers have more access to PD.

Chapter 4 Findings Chapter

4.1. Introduction

In this chapter, findings will be focused on the teachers' perceptions and knowledge regarding Mathematical Modelling. This chapter will first discuss the survey participants' demographics to better understand the ability of the survey results to be generalizable across Kazakhstan. Secondly, the findings of the analysis of teacher perceptions and knowledge regarding Real-Life problems (RLP) and Mathematical Modelling problems will be presented. The extent to which Mathematical Modelling problems are utilized by teachers in their teaching practice will also be analyzed as well as access to professional development in this pedagogical technique. Finally, the results will allow for a discussion concerning if there is a difference in the findings based on school site.

4.2. Demographics of Survey Participants

Overall, the majority of the survey participants are women (See Figure 3 a). Figure 1a shows that 70% of the participants were female. Actually, this is the common tendency for secondary schools in Kazakhstan, since there are 20% of male teachers and 80% of female teachers (NUGSE, 2014). Figure 3b details the ages of the survey participants. Figure 1b is positively skewed, which means that the ages of most of the participants (66%) are below 40 years old. The greatest number of teachers are from 20 to 29 years old (36%). Thus, the majority of survey participants were over the age of 30 which matches the age range of the majority of Kazakhstani teachers (NUGSE, 2014). Perhaps, the reason might be, that most of the surveys were collected using electronic devices, perhaps this could have deterred elder teachers from participating in this survey.

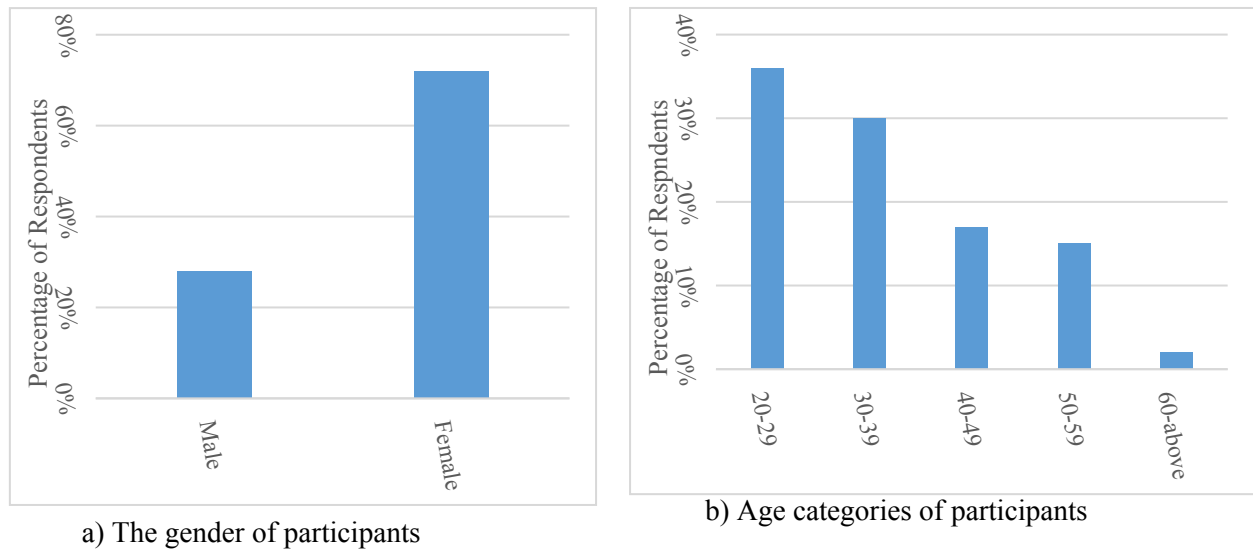


Figure 3. The gender and age of participants

However, since about 36% of the participants were less than 30 years old it is not surprising that 40% of the respondents had only 1 to 6 years of teaching experience (see Figure 4a). Figure 2b demonstrates, that most of the participants are from the Northern part of Kazakhstan (42%) while the secondary largest group were located in the South of Kazakhstan (31%). Thus, Central and Eastern Kazakhstan have the least number of participants. Perhaps, the reason for this distribution may be due to the fact that according to the population spread of Kazakhstan, the majority of the citizens (about 65%) live in South and North Kazakhstan (MoNE, nd). Moreover, the largest cities of Kazakhstan, (i.e., Nur-Sultan, Almaty and Shymkent) are located in these two regions. In addition, the population living in cities has more access to the internet (NUGSE, 2014, p. 37). Since the majority of the survey participants took the survey electronically this would favor the areas in Kazakhstan with the most stable internet access. More than 95% of respondents had at least a bachelor's degree, and 55% of them have an educational degree (Figure 4 b.). Educational degree in Kazakhstan means a degree above the bachelor's degree. Statistics of overall population shows, that 87.9% of teachers in Kazakhstan have completed higher education (NU GSE, 2014),

subsequently the current survey results have similar demographics as the entire Kazakhstani teachers’ population.

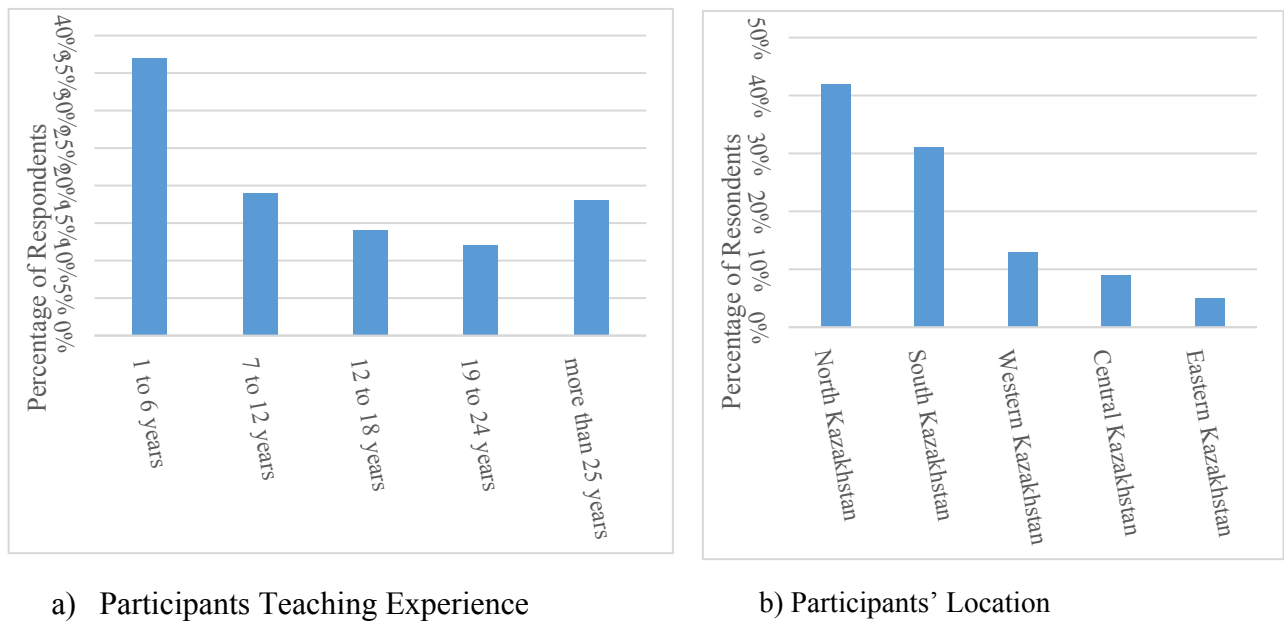
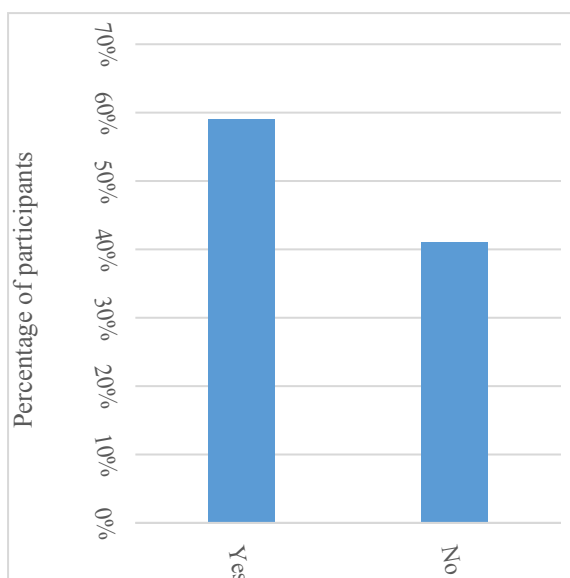


Figure 4. Participants Teaching Experience and their location.

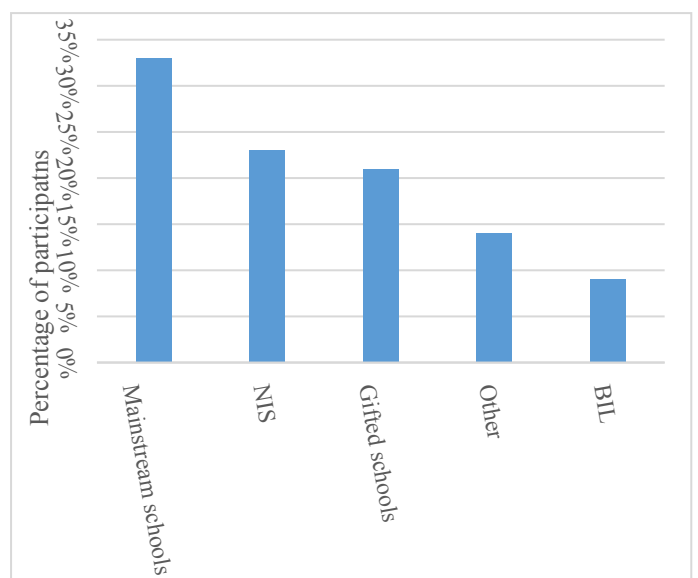
Kazakhstan has a number of different types of public and private schools, which are differentiated according to ability of students or according to ability of parents to pay for the schooling of their children. Governmental public schools of Kazakhstan are totally free for students, and in general mainstream schools are the most popular schools, which educate the majority of the students. Beyond mainstream schools, there are public schools, which work with “gifted” students only. Those schools select the students by examination results. For instance, Nazarbayev Intellectual schools (NIS) or “Bilim Innovation lyceums” (BIL) accept students after the sixth grade by the result of their own internal tests. BIL schools were formerly known as Kazakh Turkish Lyceums (KTL). These schools are a network of schools across Kazakhstan, which are totally free for students, due to the fact they are funded by the government. Moreover, these schools have more financial support from the government, than other mainstream schools. In this research NIS schools are going to be reviewed separately from other gifted schools due to its special status in Kazakhstan. NIS and BIL schools, were

the first schools, to start using international textbooks from Oxford and Cambridge (Yakovets, 2014). There are also governmental public schools such as gymnasiums, “Daryn” school, and lyceums, which are also schools for gifted students, however they are not as popular nor as well funded as NIS and BIL. Therefore in this research they are going to be in different category and will be named as “gifted schools”. Beside governmental schools, there are private schools in Kazakhstan, which are not funded by the government. Due to the large number of free mainstream schools, private schools are not very popular in Kazakhstan. Finally, there are schools, which are called “Special” schools. These schools are governmental schools, which are oriented towards specialized training for athletes or for inclusive students. In this study, “Private” and “Special” schools will be categorized as “Other” schools.

The majority of the respondents are from mainstream school (33%, see Figure 5b). The next largest groups of respondents came from NIS schools (23%), and “Gifted” schools (20%). The rest of the respondents taught at BIL (8.6%) and “other” schools (14.4%). Most of the participants are the teachers of secondary school students (middle and high school), therefore only 10% of the respondents are teachers of primary school.



a) Educational degree of Participants



b)

Work location of participants

Figure 5. Participants Educational Degree and Type school where they work.

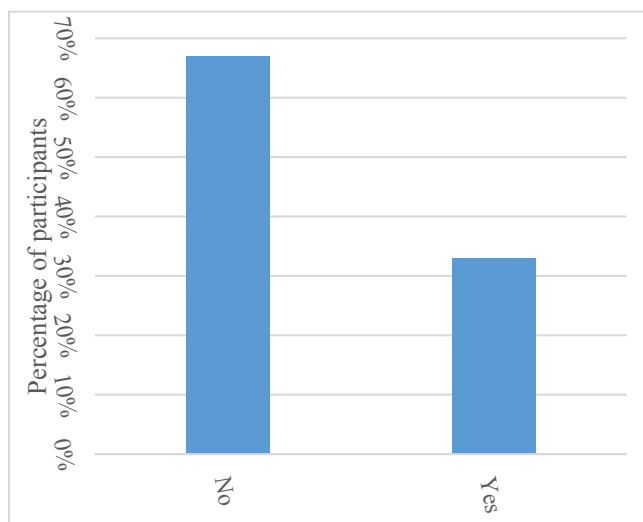
4.3. Do teachers understand Mathematical Modelling?

The hypothesis of this study is that teachers of Mathematics in Kazakhstan are not familiar with Mathematical Modelling (MM). The survey contained questions that allowed for the determination of teachers perceptions about their familiarity with MM as well as their knowledge of MM problems in general. This subsection will provide different methods of analysis to demonstrate teachers' level of understanding of MM.

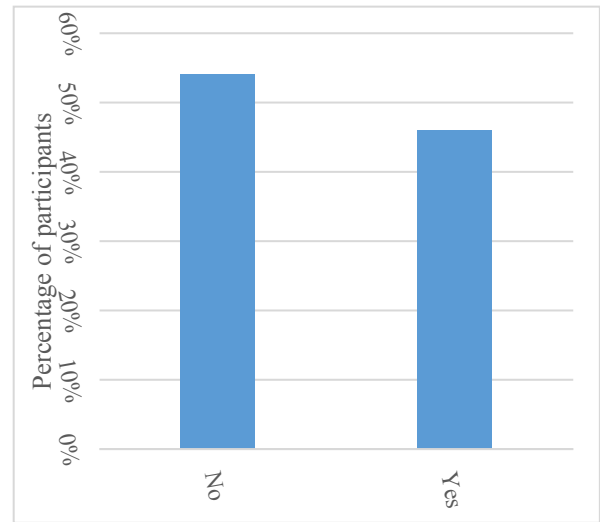
4.3.1. Teachers Perceptions about their Familiarity with Mathematical Modelling

In order to understand the perceived degree of their understanding of Mathematical Modelling, the survey included direct questions, such as “Are you familiar with Mathematical Modelling”, “Is collecting Data a part of MM?”, “Are you familiar with statistical modelling?”, and “Are you familiar with PISA typed questions”. The reason why one of the questions asked about the PISA exam is that the mathematics section of the exam is mainly focused on Mathematical Modelling (Blum, et al., 2007). All the descriptive results of the questions above are shown in figures 6a-6d. As shown in the figures, almost 70% of participants said, they are not familiar with PISA questions (Figure 6a). However, 46% of respondents perceive that they are familiar with Mathematical Modelling (figure 6b). This

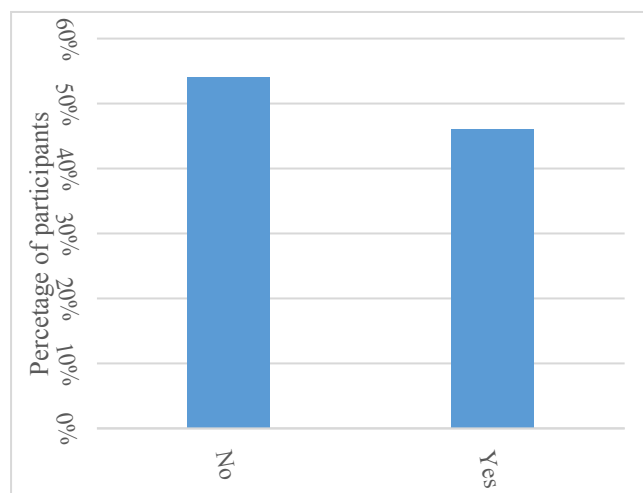
means, that almost half of the survey participants claim that they are familiar with Mathematical Modelling. The same number of teachers think, that collecting data is an element of Mathematical Modelling (figure 6c), which is correct. However, only 33% of teachers are familiar with Statistical Modelling (figure 6d). Statistical Modelling is a type of Mathematics that is not a standard part of secondary school curriculum in Kazakhstan. However, knowing Statistical Modelling allows teachers and students to analyze the data collected from real life situations during MM activities. Therefore, results are showing, that only 1/3 of the teachers are familiar with Statistical Modelling, therefore only 1/3 of teachers could teach their students how to analyze the data collected from real life situations.



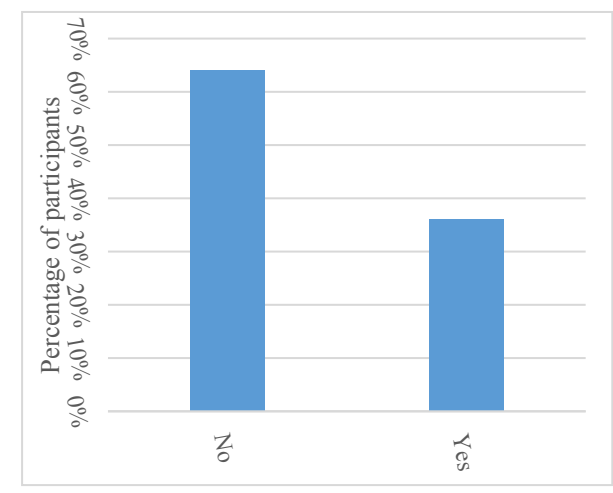
a) Familiarity with PISA questions



b) Familiarity with MM



c) Thinks collecting data is MM



d) Familiar with Stat. Modelling

Figure 6: Participant Familiarity with Mathematical Modelling and its components

The survey contained several questions that could be used to assess teachers' knowledge about MM. The survey respondents were asked to categorize what types of mathematical problems might be actual examples of MM. Figure 7 shows teachers opinions regarding the categorization of these example type problems. As it seen in figure 7, more than half of the respondents think that real life problems are examples of MM. Which means, that 60% of teachers think, that MM is related to real life problems, therefore the other 40% do not think they are examples of MM. 60% of respondents correctly connected MM to data analysis and data collection. However, a number of participants incorrectly believed that the following were MM examples: word problems (50%), speed problems (37%) and game style questions (25%). This shows that at best from 50% to 60 % of the respondents can distinguish between correct and incorrect examples of MM. Thus, a number of mathematics teachers seem not to be familiar enough with MM to select correct MM examples.

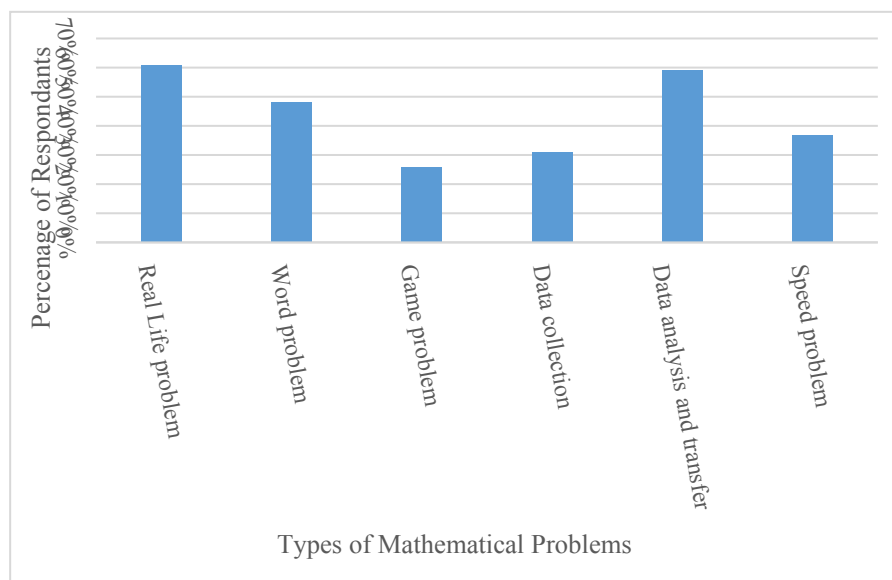


Figure 7: Teachers Responses about elements of MM

4.3.2. Teachers' Knowledge about Mathematical Modelling

In order to further determine the respondents' knowledge about Mathematical Modelling the survey was designed to contain two detailed mathematical questions which required teachers to determine if they were examples of MM or not. The first example, which was not a MM question, was as follows *"Askar had five apples. Two apples were eaten by Samal, how many apples does Askar have now?"*. For the rest of the analysis, this example will be called the non-Mathematical Modelling (non-MM) apple question. The second example, which is a MM question, was as follows:

"This is the question taken from the PISA exam. Do you think it is MM?

"Jean assumes the colony will continue to grow in the following manner:

- 1) At the beginning of each year, the colony consists of equal numbers of male and female penguins who form couples.*
- 2) Each penguin couple raises one chick in the spring of each year.*
- 3) By the end of each year 20% of all the penguins (adults and chicks) will die.*
- 4) One year old penguins will also raise chicks.*

Based on the above assumptions, which of the following formulae describes the total number of penguins, P , after 7 years?"

For further analysis, this example will be referred to the Mathematical Modelling PISA (MM PISA) question.

The answer options for both questions was yes or no. For this research analysis, the answers to these two questions were scored. The MM PISA question earned 2 points for "Yes" and 1 point for "No". The non-MM apple question was reverse scored (i.e., earning a 1 for Yes and a 2 for NO). According to the results of the SPSS analysis, the averages for the two questions were, 1.3 for non-MM apple question and 1.6 for MM PISA question (see Table 1). These two questions were analyzed using a paired T-test analysis (see Table 1).

According to the results, the mean of the MM PISA question is 1.6, which in general is higher than the mean of non-MM apple question. The T-test analysis in Table 1 shows that these averages are significantly different ($p= 0.000$, see table 2). This would seem to imply that on average the teachers understand MM in terms of selection of the correct question type. This implies that overall the majority of the respondents correctly stated that the MM PISA question was an example of MM. Thus, one could say maybe teachers in Kazakhstan do have a significant knowledge of MM regardless of their familiarity with MM and its components.

However, since the two averages were close in value further analysis was undertaken to probe the teachers' depth of understanding. When comparing the respondents answers to the two questions above, it was determined that there is a moderately positive correlation between those two scores, which is unusual. The correlation can be seen in Table 1. If the averages imply that teachers mostly understood MM then the correlation should have been strongly negative between the two questions. For example, if a particular teacher knows Mathematical Modelling, he would answer yes for the MM PISA question and no for non-MM apple question. The correlation between these two values should be a negative 1. However, if the teacher answered yes to both questions the correlation would be highly positive, or if the respondents answered randomly then there should be a zero correlation. However, the correlation between the two paired examples shows a moderate positive correlation of 0.431 (see Tables 1 and 2). This correlation was highly significant. This implies that the teachers do not seem to really understand Mathematical Modelling since many chose both questions as examples of MM.

Table 1: The means and correlation of MM and non-MM examples

	Mean	N	Std. Deviation	Std. Error Mean	Correlation	Sig.
Non-MM problem	1,38	111	0,688	0,065	0,431	0,000
MM problem	1,63	111	0,660	0,063		

Table 2: Paired Samples t-test of MM and non-MM examples

	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Non-MM problem: MM problem:	-,252	,719	,068	-,388	-,117	-3,694	110	,000

4.2.3. The correlation between components of Mathematical Modelling

The contradictions posed in the findings above question the real understanding of teachers about Mathematical Modelling. For further exploration of the teachers' knowledge about MM, the following questions on the survey were checked for their correlations:

- “Can collecting data be a part of MM?”,
- “Are you familiar with Stat. Modelling?” and
- Is the PISA question (example 2) from the survey MM?

As it was mentioned before, in section 4.2.1, these questions are questions which directly relate to Mathematical Modelling as they are all utilized when using Mathematical Modelling. Using SPSS, a correlation matrix for all three questions was calculated. The correlation matrix values can be seen in table 3. None of the questions have a correlation with each other since the values are all below 0,1. This is despite the fact that all of these scores should have been correlated if a majority of the teachers understood MM since they would then answer that most definitely these all are used in MM. Therefore, it may be deduced, that teachers understanding of MM is quite diverse and lacking.

Table 3: Inter-Item Correlation Matrix between elements of MM

	1	2	3
1. Can collecting data be a part of MM?	1,000	,053	-,097
2. Are you familiar with Statistical Modelling?		1,000	,005
3. Is the PISA question (example 2) MM?"			1,000

4.3.3. Effect of PD training on familiarity with Mathematical Modelling

To support the main hypothesis of this study, the relationship between Professional Development opportunities focused on MM and Familiarity with Mathematical Modelling questions from the survey was checked using a Chi-Square test. It's expected, that teachers, who are trained on MM, should also be familiar with MM questions. If these two responses influenced each other as one might expect they would then there should be a statistically significant value of $p < 0.5$ between these two cases. However, the significance value shown in table 5 is $p = 0.07$. Thus, PD has no effect on teacher understanding of MM. These results support the hypothesis, that teachers in Kazakhstan do not have a strong understanding of Mathematical Modelling and that PD does not currently support understanding of MM.

Table 4: Chi-Square Matrix: PD on MM vs. Familiarity with MM

			Are you familiar with MM?		Total
			No	Yes	
Do you attend any professional development on MM	No	Count	48	33	81
		Expected Count	44,3	36,7	81,0
	Yes	Count	16	20	36
		Expected Count	19,7	16,3	36,0

Table 5: Chi-Square Tests of PD on MM with familiarity with MM

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,208 ^a	1	,137		
Continuity Correction ^b	1,650	1	,199		
Likelihood Ratio	2,204	1	,138		
N of Valid Cases	117				

Note: 0 cells (0,0%) have expected count less than 5. The minimum expected count is 16,31.

4.3.4. Teacher Knowledge of Mathematical Modelling based on Mathematical Modelling Scores

In order to further analyze the survey results, a comparison was made concerning how participants who said, that they were familiar with MM were able to correctly select between

the non-Mathematical Modelling apples question and the Mathematical Modelling PISA question. It stands to reason that if one is familiar with Mathematical Modelling, then those participants should be able to correctly distinguish between these two questions.

Table 6 and table 7 are cross tabulation tables that show the frequency and percentage of answers concerning participant's categorizations of the questions with the main variable of familiarity with MM. In this case, cross tabulation is a method to analyze the relation visually between multiple variables. As it seen in Table 6, from those who said that they are familiar with MM, 44% said that the NM apple question was Mathematical Modelling. In addition, another 12% of these respondents said that they were struggling with this question or did not know the answer. As a result, 56% or more than half of the teachers who said they know MM, gave an inappropriate answer for the NM apple question.

Table 6: Cross tabulation of familiarity with MM and categorization of non-MM apple question

			Are you familiar with Mathematical Modelling?		Total
			No	Yes	
Non-MM problem example	I do not know	Count	8 _a	6 _a	14
		Percentage	13,6%	12,0%	12,8%
	No	Count	20 _a	22 _a	42
		Percentage	33,9%	44,0%	38,5%
	Yes	Count	31 _a	22 _a	53
		Percentage	52,5%	44,0%	48,6%

Table 7 contains the cross tabulation results for the MM PISA question. In this case, 67.3% of the teachers familiar with modelling agreed, that the question taken from PISA was a correct MM example. However, the teachers who said, that they were not familiar with MM had more correct answers than the group familiar with MM, since 77,6% of them thought that the MM PISA question was a MM example. Thus, if we compare the right answers among those who are familiar with MM with those who are not, the results show, that teachers, who are not familiar with MM have a greater percentage of correctly categorizing the MM PISA question. Moreover, those who said that they are familiar with MM were having greater

difficulty even deciding on a categorization to this question than those not familiar with MM (14,3% vs 6,9%, see Table 7).

Table 7: Cross tabulation of Teachers Familiar with MM and MM PISA problem categorization

			Are you familiar with Mathematical Modelling?		Total
			No	Yes	
This is the question taken from the PISA exam. Do you think is it MM?	I do not know	Count	4 _a	7 _a	11
		% Familiar with MM?	6,9%	14,3%	10,3%
	No	Count	9 _a	9 _a	18
		% Familiar with MM?	15,5%	18,4%	16,8%
	Yes	Count	45 _a	33 _a	78
		% Familiar with MM?	77,6%	67,3%	72,9%

The discrepancy between the teachers response based on their familiarity with MM

requires additional analysis. There are 49 teachers, who said, that they are familiar with MM.

The cross tabulation in Table 8 was made for these teachers, and their selections focused on the MM PISA and non-MM apple questions. The result of this analysis is shown in table 8. It would be expected that teachers, who said that they know MM should answer that the non-MM apple question is not an example of MM and the MM PISA question is an example of MM. However, the results of the cross tabulation shows that only 12 out of the 49 teachers (i.e., 24%) who said that they know MM answered these two questions correctly. Therefore, only 12 (9%) out of the total 132 respondents who were familiar with MM could correctly distinguish between the two problems. Therefore, this data demonstrates that the teachers who responded to the survey really do NOT understand Mathematical Modelling.

Table 8: Crosstabulation between MM PISA problem and non-MM problem for teachers familiar with MM

			MM PISA Problem			Total Responds
			I do not know	No	Yes	
Non –MM Apple problem	I do not know	Count	4 _a	0 _b	1 _b	5
		Percentage	57,1%	0,0%	3,0%	10,2%
	No	Count	2 _a	8 _b	12 _a	22

	Percentage	28,6%	88,9%	36,4%	44,9%
Yes	Count	1 _a	1 _a	20 _b	22
	Percentage	14,3%	11,1%	60,6%	44,9%

Finally, to demonstrate the validity of the previous findings an independent t-test was used to determine the significance of these results. The survey was used to create a Mathematical Modelling score for each participant by recoding data. All participants were given one point for each correct answer for the MM PISA problem example and the non-MM apple problem example. For example, if a teacher said the MM PISA problem was a true example of MM they earned one point and if they said that the non-MM apple problem was not a true example of MM they earned an additional point. Thus, someone who truly understood Mathematical Modelling would have earned a Mathematical Modelling score (MM Score) of 2 and a person who answered both incorrectly would earn a score of 0. Subsequently, the MM Scores were analyzed (there was a maximum of 2 points for each respondent). Table 9 shows the mean of the sum of answers of the respondents between those, who are familiar with MM and those who are not. Table 10 shows the analysis of the given data using an independent T-test among the responses of teachers on familiarity with MM in terms of their score. It was expected, that teachers, who are familiar with MM will have a higher mean. Table 9 shows that the average MM Score for those teachers who say they are familiar with MM is 1,121, while those who are not familiar is 1,122. These scores are very close. To test the significance between the differences of these values an independent t-test was used. The t-test assumes that the variances in the populations are equal. To test this assumption the Levene's test for equality of variances was observed. Levene's test is an inferential statistic used to assess the equality of variances for a variable calculated for two or more groups (Levene, 1960). Table 10 shows that the assumption of equal variances is proven since the variances between the two groups was not statistically

significant ($f=0,456$; $p=0,501$). The means between the two groups were tested using the t-test for equality of means and it was determined that the means were not significantly different from each other ($t=0,014$; $p=0,989$, see table 10). Therefore, there is not any difference in MM knowledge scores between the two groups who said that they are familiar with MM and those who are not.

Table 9: Group Statistics of MM Scores

Are you familiar with Mathematical Modelling?	N	Mean	Std. Deviation	Std. Error Mean
No	58	1,1207	,65098	,08548
Yes	49	1,1224	,59974	,08568

Table 10: Independent Samples t-test of Sum of examples variable

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	df	Sig. (2-tailed)
Sumofexamples	Equal variances assumed	0,456	0,501	-0,014	105	0,989

4.3.5. Summary of Teacher Knowledge about Mathematical Modelling

The results of the previous sub sections demonstrated that teachers are not familiar with Mathematical Modelling. According to descriptive statistical analysis, only 9% of overall participants of the survey could correctly categorize the examples of Mathematical Modelling. Also, it was seen that, teachers familiar with MM had exactly same MM Scores as those not familiar with MM. In addition, there was no correlation between the elements of MM.

4.4. Do Mathematics teachers participate in Professional Development?

Professional development plays a crucial role in the implementing of Mathematical Modelling in the secondary schools. However, PD on MM should not be only teaching the theory, according to Gaston and Lawrence (2015) training in PDs should be complex starting from how to create the MM problem to organizing and assessing the problems. Therefore, this section will discuss the impact of PD on teachers' understanding about Real-Life problems and Mathematical Modelling.

4.4.1. Participation in Professional Development in general

Figure 8 details the teachers' attendance on all PDs. 60% of participants had participated in local and state Professional developments. 10% of teachers had PD at the international level. However, the most interesting response to this part of the survey is that only 14% of the respondents say that they had PD at the school level. Finally, 20% of the teachers didn't attend any professional developments at all. From here, it may be concluded, that one fifth of teachers never had any PD's, and most of the Mathematics teachers are not attending any school trainings (87%). Refer to Figure 6 for a breakdown in PD categories.

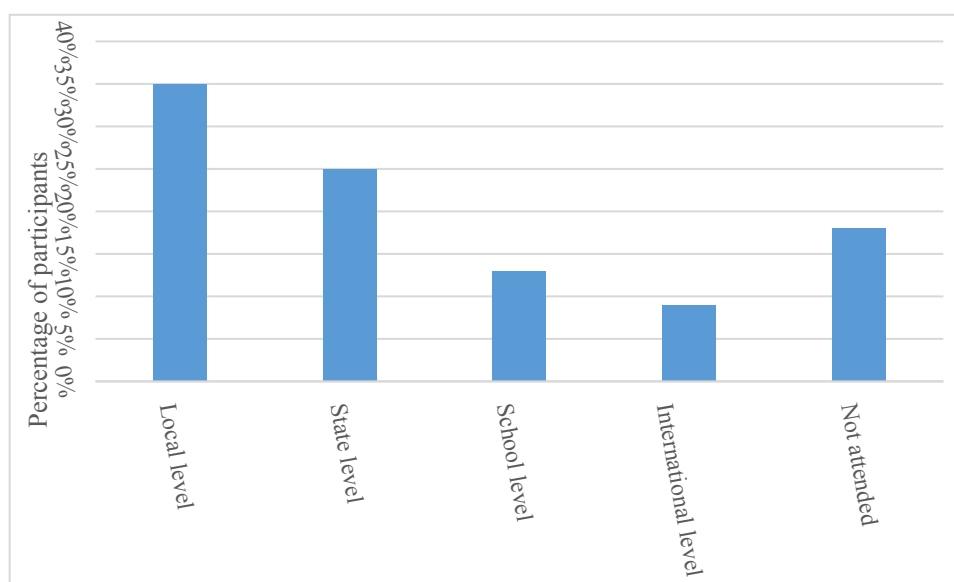


Figure 8: Teachers' attendance on different PD's

4.4.2. Mathematics teachers participation in Mathematical Modelling Professional Developments

Figure 9 clearly shows the picture of attendance of teachers at special PD regarding real life situations and Mathematical Modelling. As seen in figure 9, in general only one third of teachers had participated PD about Real life or MM. The rest 65% to 70% didn't attend any PD on MM or RLP. The difference between attendance of PD on MM and attendance of PD on RLP is very small.

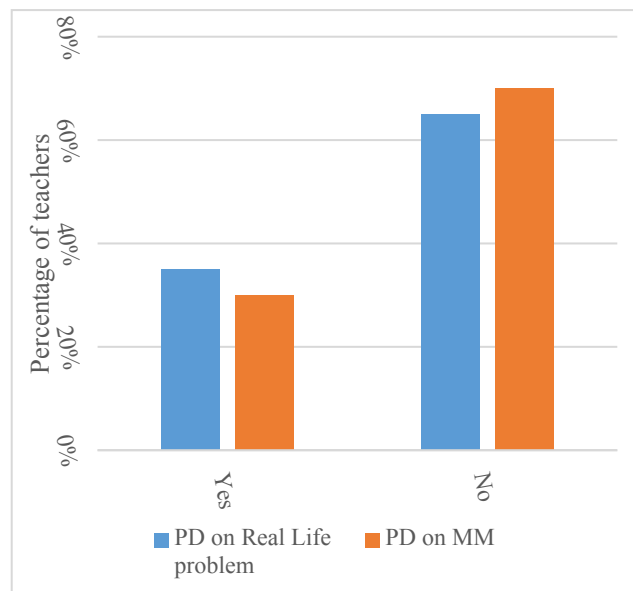


Figure 9: Attendance at PD focused on RLP and MM.

Professional development taken based on the context of the teachers' work location is shown in Figure 10. NIS has the largest number of PDs focused on real life problems, while schools such as Daryn, gymnasium, BIL and lyceums are having the least. Thus, it seems unlikely that most of the schools working with gifted students are teaching using applications of Mathematics.

Nevertheless, according to Figure 11 almost 70% of Mathematics teachers' agree that Mathematics must not be taught only theoretically. Which shows, that teachers in general agree that the application of Mathematics should be taught in secondary school classes.

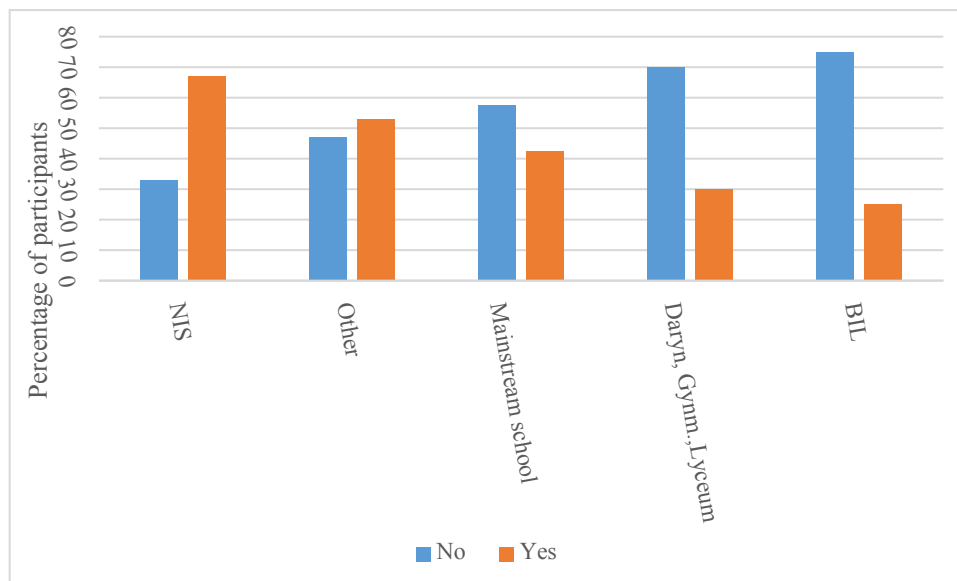


Figure 10: Attendance at PD focused on Real life situations by school type

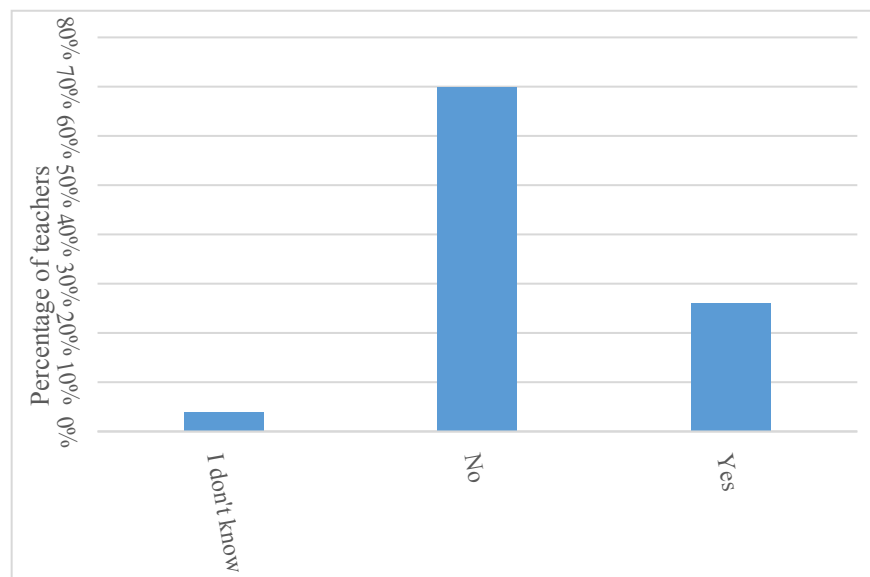


Figure 11: Teachers' opinion regarding teaching Mathematics theoretically

4.4.3. Connection of Professional Development to teachers familiarity with Mathematical Modelling

In order to determine if PD had an effect on teachers' knowledge about MM an analysis was completed to find the correlations between teachers' PD on real-life problems and MM and teacher knowledge about these topics. It's expected, that teachers who attend PD concerning real-life and MM problems should correlate with their knowledge concerning this topic and some MM terminologies. In table 11, the biggest correlations are between the

variables “Familiar with MM” and “Familiar with Statistical Modelling” (i.e., $r=0.533$) and the variables of PD in MM and “collecting data is part of MM” (i.e., $r=0.475$). Professional Development in real life problems has a moderate correlation with PD in MM (i.e., $r=0.42$). This may mean that teachers who attend PDs about RLP are more likely to attend PDs about MM, or it may be interpreted as teachers who are having PD about RLP learn about MM at

Table 11: Inter-Item Correlation Matrix of PD elements

	The elements of MM, in horizontal form						
	1.	2.	3.	4.	5.	6.	7.
1. Do you attend any PD on MM?	1,000	,208	,427	,132	,208	,166	,120
2. Are you familiar with PISA typed questions?		1,000	,352	,327	,219	,377	,314
3. Have you attend any PD on RLP?			1,000	,287	,109	,185	,160
4. Are you familiar with MM?				1,000	,288	,533	,475
5. Are you familiar with Pearson's r value?					1,000	,417	,044
6. Are you familiar with Statistical Modelling?						1,000	,330
7. Can collecting data be a part of MM?							1,000

the same time. However, there are only very weak or no correlations with other elements of MM. For instance, PD in MM or Real Life problems does not have a correlation with teacher familiarity with MM, Statistical Modelling or Collection of Data. This is concerning since statistical modelling and data collection are components of MM problems. Therefore, it may mean two things, the quality of those PD's are very weak or teachers were attending PDs on different topics.

4.4.4. Mathematical Modelling and undergraduate training

Figure 12 shows that overall teachers agree, that UG institutes are not teaching Mathematical Modelling. Moreover, the hypothesis about teachers' lack of understanding of

MM may be supported by the descriptive statistics shown in figure 12. According to graph, only 36% of teachers think, that institutes teach how to explain MM in the secondary school. Thus, the lack of understanding is compounded since mathematics teachers seem to not have been taught their use in their university training.

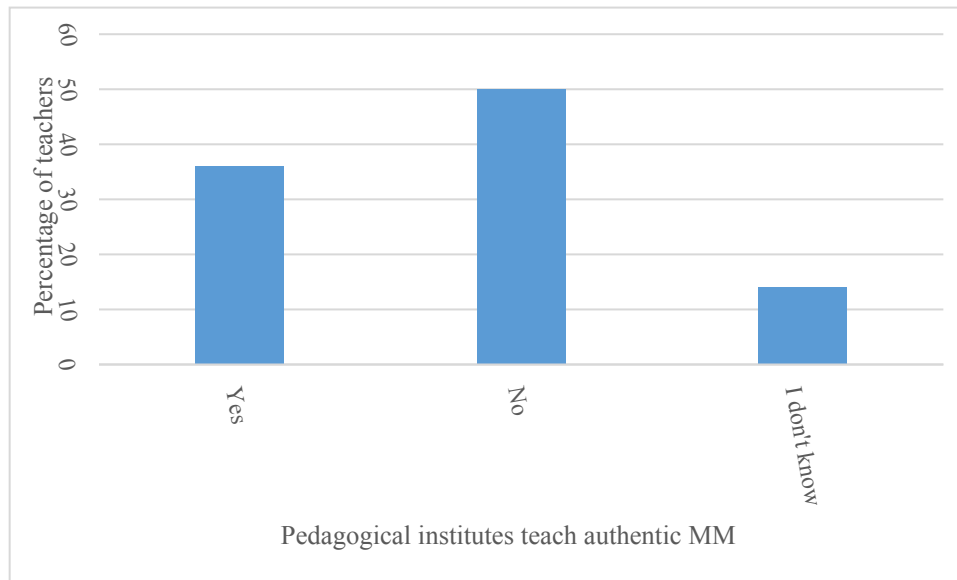
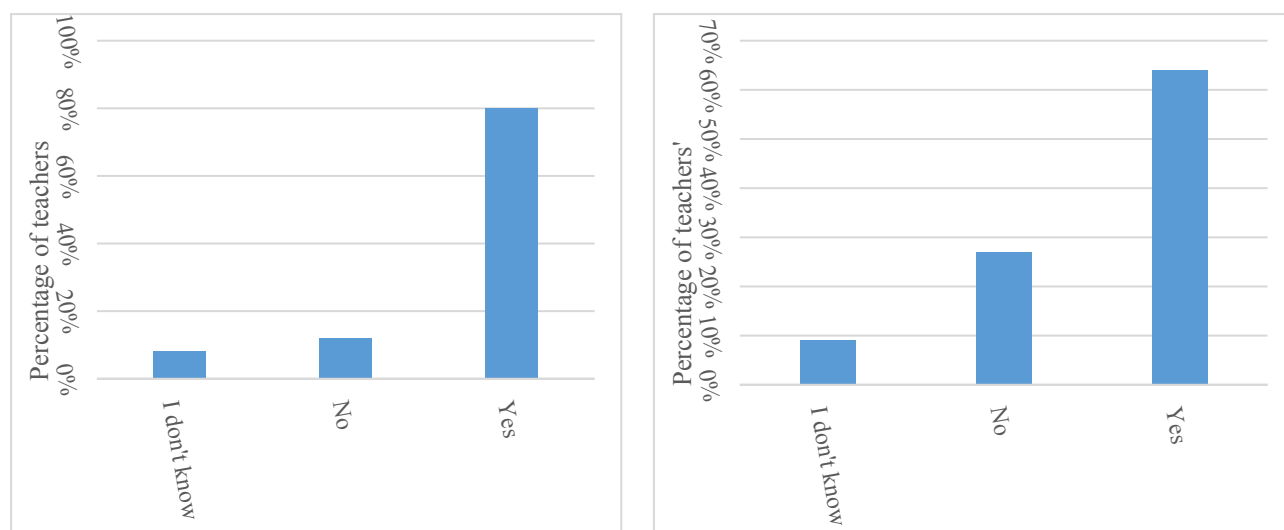


Figure 12: Pedagogical institutes teaches authentic MM

4.5. Teacher opinions concerning the teaching of MM in their classes

In figure 13a, it can be seen that only 10% of respondents think that MM is not beneficial in mathematical classes, while 80% think that it's beneficial to use Mathematical Modelling in these classes. Moreover, in graph 13b it's clearly seen that 60% of teachers would like to use Mathematical Modelling in their classes. However, comparing figures 13a and 13b shows a difference of 20%, which might mean, that teachers agree that MM is beneficial, but do not wish to use it in their class. It may mean, that some teachers who agree that MM is beneficial to use in class due to some obstacles do not want to use it in their classes.



a) It is beneficial to use MM?

b) Would you like to use MM in the class

Figure 13: Teachers opinions about the benefits of MM and their desire to use it in their classes

4.6. Perceived Obstacles to teaching Mathematical Modelling in Schools

To determine the perceived obstacles of teaching MM in the class, the correlation between perceived obstacles were analyzed. Table 14 shows the correlations between the possible obstacles that could make teaching MM difficult in school. The Reliability of the table is good, since the Cronbach's Alpha value is 0.800. According to table, the variable that general conditions in schools make it difficult for teaching MM has a correlation greater than 0.341 with each of the other obstacles assessed. The largest correlation is between the need for a special textbooks and that of students dislike for MM, (i.e., 0.54 and 0.508, respectively). In addition, the strongest correlation is between the variables of "Students are against MM" and "Parents are against MM" (i.e., $r=0.653$). The next biggest correlation is between "the need for a special curriculum and the need for special textbooks" (i.e., $r=0.613$). This could be caused by the idea that textbooks and curriculum are similar.

Table 12: Correlation between Variables that could be obstacles to teaching MM

	1.	2.	3.	4.	5.	6.
1.Parents are against MM	1,000	,653	,436	,449	,339	,191

2.Students are against MM	1,000	,499	,508	,265	,224
3.Administration are against MM		1,000	,341	,262	,198
4.The general conditions in my school make it difficult to teach MM.			1,000	,542	,456
5.It requires special textbooks to teach MM				1,000	,613
6.It requires special curriculum to teach MM					1,000

It's clearly seen that in general teachers agree that MM is a beneficial method to be taught in secondary schools. However, some teachers think, that it is difficult to teach MM in the class due to some obstacles. Therefore, the survey included questions about whether teachers were willing to use MM in their classes due to its benefits, or whether they are not willing to use it due to obstacles to its implementation. To answer this question, the survey results were analyzed. The survey included questions about the obstacles to using MM and the benefits of using MM. Teachers were asked to either agree or disagree with the statements about obstacles and benefits to the use of MM. For instance, in obstacles section, there were question like, does MM requires a lot of time or are students against the use of MM. Benefit questions asked if MM was useful for students, or if MM was interesting for students. For each statement they agreed with one point was awarded. The average of all respondents' answers related to the usefulness of MM" was one variable, and the average of all obstacles to MM was the second variable. Both of the variables were analyzed using a paired T-test. The results of that test are shown in table 13. According to table, the mean of the "obstacle" variable is greater than the mean of "useful" variable. The test is significant; therefore, it may be concluded, that teachers tend to think that MM has more obstacles than benefits. This result may not be too surprising given that figure 14 shows that 60% of respondents think that lessons will become unpredictable when MM is used in the classroom.

Table 13: Paired Samples Statistics of mean of useful with mean of obstacles

	Mean	N	Std. Deviation	Std. Error Mean
MeanUseful	,3889	74	,17760	,02065
Meanobstacle	,4966	74	,26005	,03023

Table 14: Paired Samples t-test of mean of useful with mean of obstacles

	Mean	t	df	Sig. (2-tailed)
MeanUseful - Meanobstacle	-,10773	-3,565	73	,001

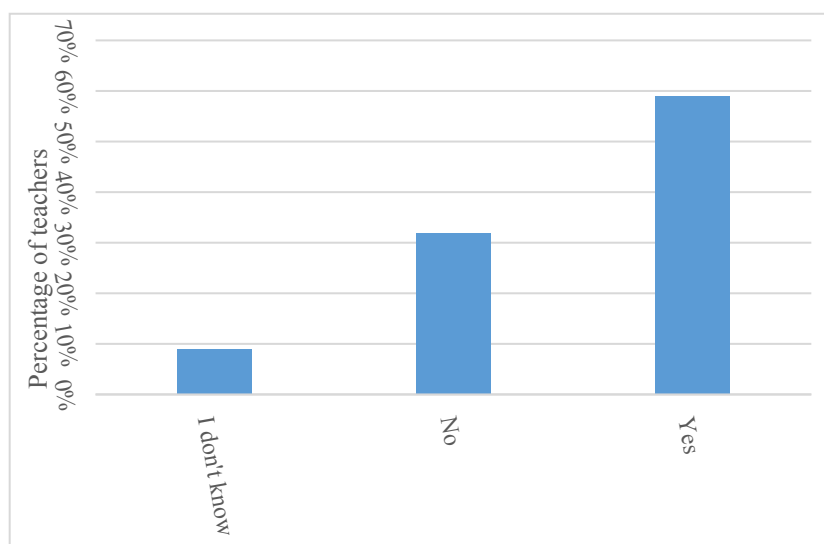


Figure 14: Teachers' opinion about the unpredictability of lessons using MM

4.7. The results according to school

Kazakhstani policy makers are trying to implement different educational reforms in order to create the best educational system possible. NIS schools are the outcomes of part of these educational reforms. The thought is that after educational practices are tested at NIS school, the best educational experiences will be spread among other schools in Kazakhstan (Shamshiddinova, et al, 2014). In 4.2, teachers' perception about the use of real life problems in their classes was discussed. Therefore, this section will consider the subject in the context of Kazakhstani schools. In figure 15 and figure 16, it's clearly seen that NIS schools have the highest results concerning their perceived familiarity with MM and with PISA questions. In

figure 15, schools for gifted students have the lowest result, with only 22% of teachers being familiar with MM. Mainstream schools are in the middle, however we should not forget that in section 4.2 teachers in general were actually not that knowledgeable with MM.

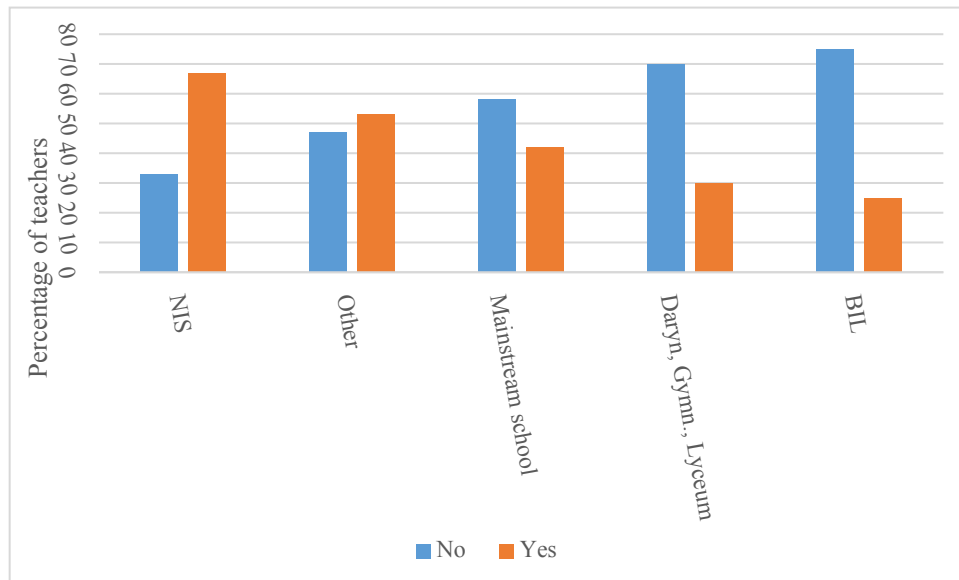


Figure 15: Teacher familiarity with MM by teaching location

NIS schoolteachers, over 60%, are saying they are familiar with PISA type questions (See figure 16). However only 10% of teachers in public schools are familiar with PISA typed questions. Perhaps, this might be one reason why Kazakhstan has only slightly above average results on the PISA exam.

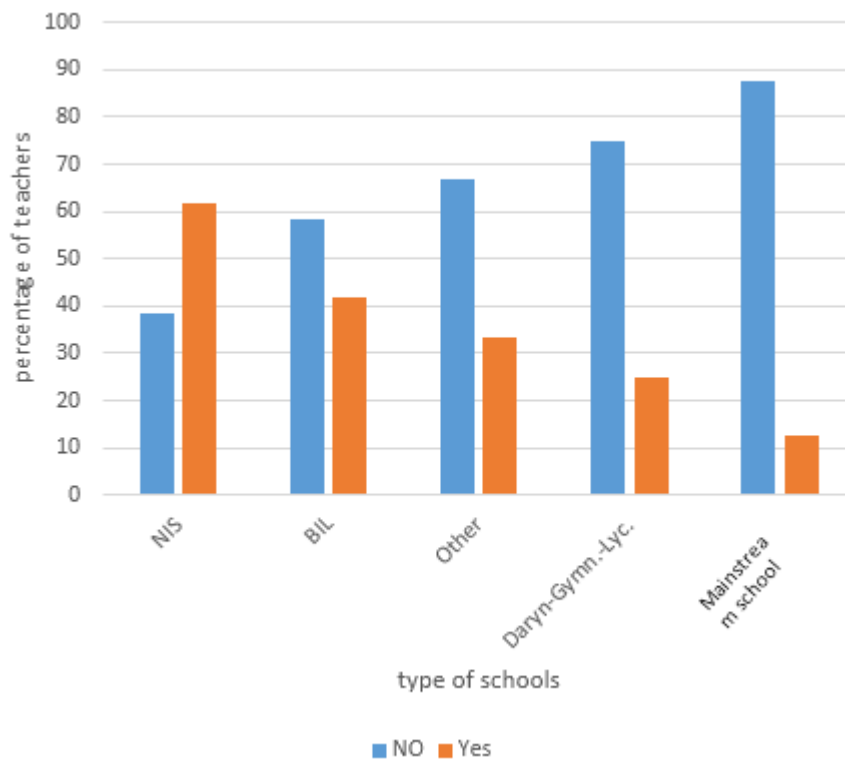


Figure 16: Teacher familiarity with PISA style questions

As shown in Figure 11, teachers in general tend to think, that mathematics should not to be taught only theoretically. Figure 17 shows the percentage of teachers who answered this question by the school they teach at. Public schools which in general are not familiar with PISA typed questions (10%), mostly think that Mathematics should be taught theoretically (i.e., 35%). In addition, a large percentage of BIL schoolteachers, who are the least familiar with MM (25%), seem to believe that Mathematics should be taught only theoretically (i.e., 33%). NIS schoolteachers, who say they are the most familiar with MM in figure 15 and with PISA style questions figure 16, have only 20% of teachers who think that Mathematics should be taught only theoretically. However, their results are much different from those of public school (35%) (See figure 17). However, only 12% of gifted school teachers agree that Mathematics should be taught theoretically, which means teachers, who work with these gifted students understand, that their students require applications within their Mathematics lessons.

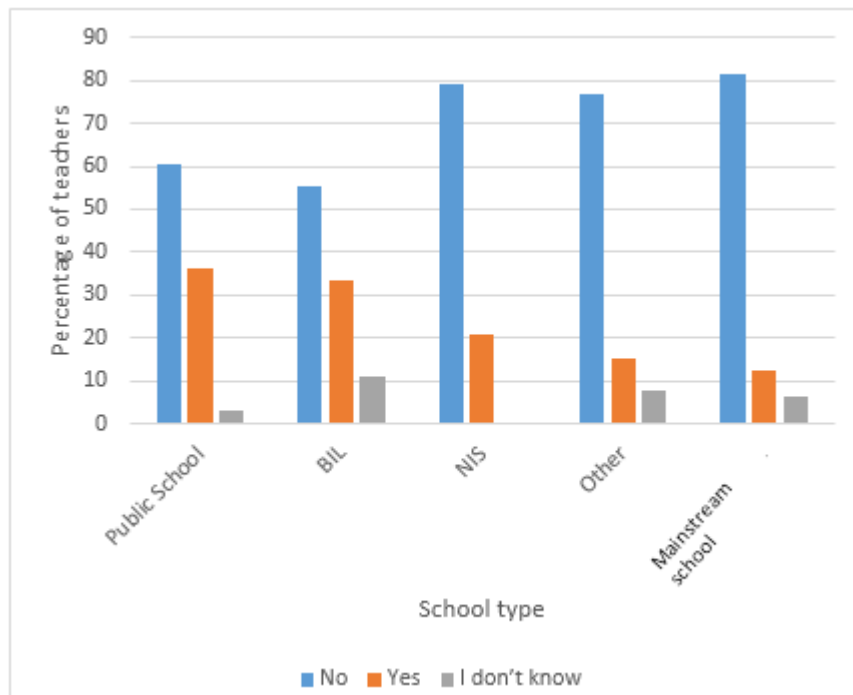


Figure 17: Teacher beliefs of teaching Mathematics only by theoretical methods by school type.

4.7.1. Teachers' perception of the use of MM by school type.

Figure 18, shows the teachers' responses about whether the non-MM apple question was a wrong example of MM. According to the graph, teachers from schools for gifted students (Daryn, Gymnasiums and Lyceums) have the highest percentage of right answers (60%), NIS is the second (42%). The lowest percentage of correct answers are obtained by teachers from public and BIL schools, with only 25% of teachers answering correctly.

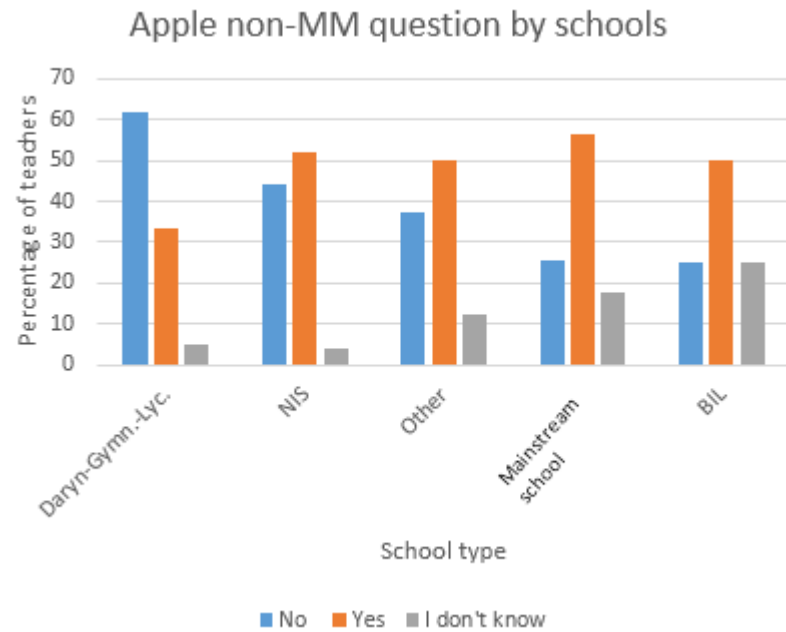


Figure 18: Example of non-MM question by schools

When the same comparison is completed for the MM PISA example, it is determined that the majority of teachers agree that this is an example of Mathematical Modelling. Almost 85-90% of NIS and BIL schoolteachers answered this question correct. The lowest percentage (63%) was obtained by public school teachers (see Figure 19).

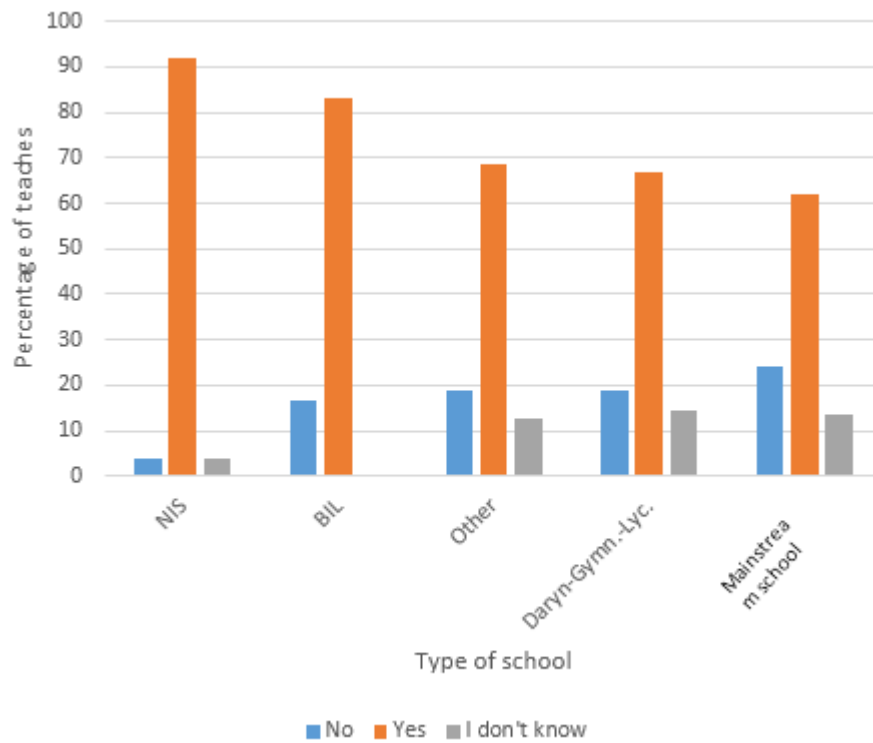


Figure 19: Teacher knowledge that the MM PISA question was a true example of MM

As it was mentioned before, the right answers for these two question examples example transformed into a MM Score. If respondent answered both examples correctly, they gained two points, one correct answer was awarded one point and no correct answers was awarded zero points. Figure 20 shows the distribution of scores school type. The school with the largest percentage of correct answers was NIS schools (40%), this may be the outcome of systemized professional developments. The school for gifted students had 36% right answers. Public and Other schools have from 12% to 20% maximum scores, however they both have the biggest number of wrong (zero points) answers. BIL school had the least percentage of totally correct answers (4%). It may be concluded, that Public, Other and BIL schools are not strong on teaching MM, therefore require targeted PD on MM.

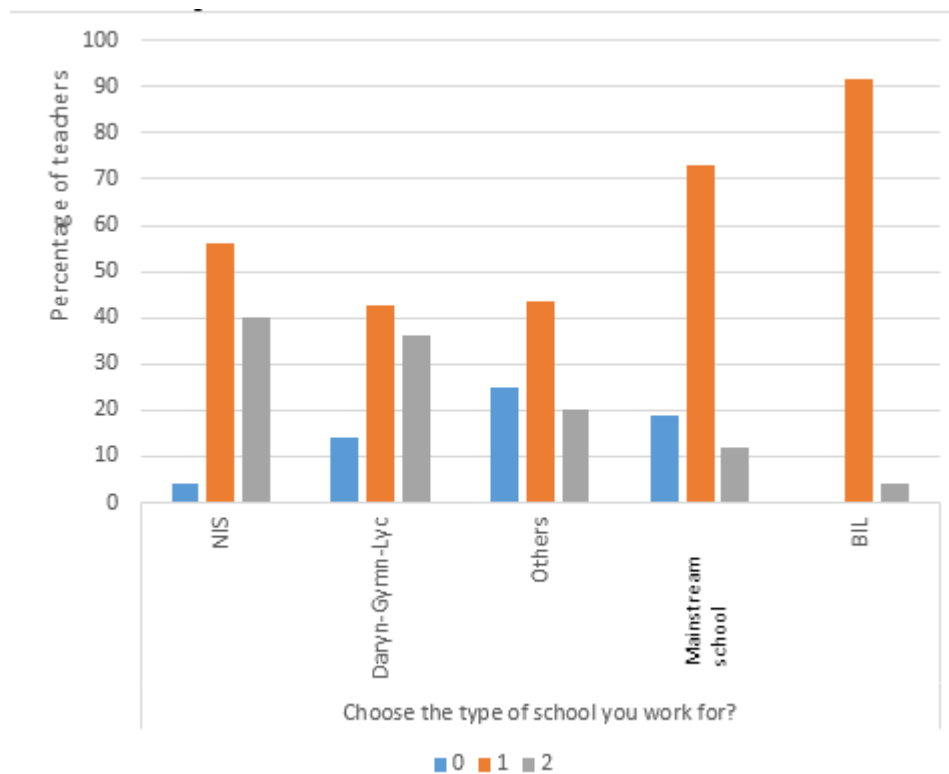


Figure 20: MM Scores by School Type.

Finally, figure 21 shows the information about conditions to teach MM in schools. In general, 40-50 % of teachers of almost all the schools think that in general conditions in their schools are not conducive towards the teaching of MM. Moreover, surprisingly public schools teachers have the highest percentage of teachers who think, that they have good conditions to teach MM (49%). This finding is interesting since public school teachers appear to know the least about MM.

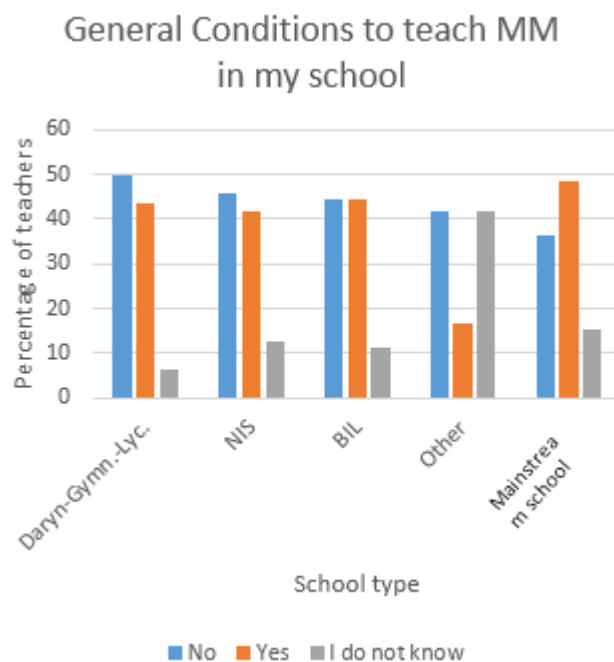


Figure 21: Teachers opinion about favorable conditions in their school towards teaching MM

4.8. Conclusion

This chapter showed that the demographics of survey respondents were similar to that expected given Kazakhstani teaching statistics. Section 4.2 determined by analysis of the data in four different ways that teachers are not familiar with Mathematical Modelling. Section 4.3. demonstrated the results concerning Professional Development. Teachers' who were participating in MM or RLP training in reality were not familiar with MM. Sections 4.4. and 4.5. show that in general teachers are willing to use MM in their classes. However, there are fears and obstacles, which makes teaching MM difficult. Sections breaks down the survey data by school type. As it seen in the analysis in section 4.6., teachers of NIS are the most familiar with MM, and teachers of BIL and mainstream schools are the least familiar with MM. Overall the information and findings in this chapter will be considered in the discussion chapter in relation to past research.

Chapter 5 Discussion

This section is targeted at discussing the findings presented in the previous chapter, and answering the research questions which guided this study. Moreover, discussions of this chapter will be closely connected with the past literature.

5.1. Teachers' perceptions about Mathematical Modelling and participation in

Professional Development

The result chapter showed that in general the majority (70%) participants of the survey are, young teachers, teachers below 40 years old. Neves and Amaro (2012) mentioned, that it is perceived that elders are less familiar with ICT in comparison with young people, perhaps this is the reason why young teachers were participating in the electronic survey more often than the elder teachers. Records show, that 80.2% of teachers in Kazakhstan are female, thus the 72% of the survey participants compare well to this value (Ayubayeva, et al, 2014). In addition, the results of the survey showed that, almost 95% of teachers in general have at least a bachelor's diploma, while 55% of them have a Master's or PHD degree. The reason for this educational background is that Kazakhstan requires subject teachers to have at least an educational bachelor's degree (MoJRK, 2014). Finally, as it was seen from the findings chapter, almost all of the regions of Kazakhstan participated in the survey, and the respondent spread was fairly well distributed according to population of the regions of Kazakhstan. Therefore, all this information above is consistent with the demographics of teachers in general, subsequently these findings can be generalized to all of Kazakhstan.

The number of schools in Kazakhstan is 7384. Almost half of them are small multi grade schools. There are a number of different classifications of secondary schools in Kazakhstan. Beside mainstream schools, there are schools, which are private, specialized, gymnasiums and lyceums. Schools for gifted students have more funding than mainstream schools, and their students are selected by special exams. NIS and BIL schools are schools

for gifted students which were analyzed separately because they are both within a network of schools whose students are showing high results on different educational competitions and overall educational results on assessments. Moreover, NIS schools are the schools, which were created by the initiative of first president N. Nazarbayev in order to try out the best new educational practices, which would then be spread over other secondary schools of Kazakhstan (OECD, 2014, p. 32). Therefore, it's clearly seen from the survey that NIS has the greatest participation in real-life problem and Mathematical Modelling (MM) professional development trainings with more than 40% of teachers attending these type of professional developments (see figure 8). They also had the biggest familiarity with Mathematical Modelling (67%, see figure 12). However, despite high results on educational Olympiads, the BIL schoolteachers in general are not attending special trainings. Only 20% of teachers at this school attended PD on RLP or MM, moreover only 20% of the teachers were familiar with MM.

5.2. Teachers' knowledge about Mathematical Modelling

Kazakhstan participated in the PISA examinations in the years of 2009, 2012 and 2015 (OECD, 2010; OECD, 2014; OECD 2016), however this study did not consider the results of PISA 2015, because Kazakhstan results were not compared with other country results due to construct coverage. On the 2009 PISA examination, Kazakhstan took 56 place out of 74 countries on Mathematics, and on the 2012 exam took 49th place among 65 countries (OECD, 2014). In both cases, Kazakhstan had results below the average score. As it was mentioned in literature review chapter, the experts from PISA claim, that students from Kazakhstan are strong theoretically, but weak on application (OECD, 2014). PISA Mathematics examination has a section called "Mathematical Literacy", which attempts to determine students' ability to work with problems concerning real life situations (OECD, 2014). According to Blum, et al. (2007), even though Mathematical Modelling is the central focus of PISA mathematics

questions, students are not expected to use all the elements of the MM framework (see Figure 1) as they only need to be active problem solvers. According to findings chapter of this study, only 33% of respondents had any familiarity with the PISA style questions. Perhaps, teachers know MM, but did not know PISA typed questions; therefore, teachers' perceived familiarity and knowledge of MM was analyzed.

The survey results show that 46% of teachers think that they are familiar with Mathematical Modelling questions. It is interesting that the number of teachers, who claim to know MM is higher than the number of teachers who know about PISA questions due to their connection to MM. Therefore, what do teachers think about components or elements of the Mathematical Modelling. In chapter 4, according to figure 5 it was seen that 50% of respondents think that MM is word problems, speed problems or even a game. In Kazakhstan, questions on speed are perceived as standard tasks where students are tested for their ability to use the formula "distance = speed x time". Moreover, a speed problem is an example of a word problem. A word problem is a mathematical exercise where the main information is given in a text form, but not in Mathematical notation (Verschaffel, Greer, & De Corte, 2000). Usually, students are required to create an equation taken from the text and solve it. Therefore, word problems are not synonymous with Mathematical Modelling, and it may be deduced that at least 50% of teachers really are not familiar with MM. Schoenfield (2013) had similar results in his study and showed that teachers understand Mathematical Modelling as a variation of problem solving questions or as a word problem.

The survey contained two questions, which consisted two problems. One problem was a simple non-MM word problem, and second problem was a MM question taken from a PISA exam. Teachers were asked to give their answers whether those questions are MM or not. Those two examples were analyzed by detailed Descriptive Statistics. The result showed that teachers agreed that the PISA question is more MM, than non-MM problem. Perhaps, one of

the reasons for this large percentage agreement was that the survey included a citation to the fact that the specific example was taken from a PISA exam. Thus, teachers may have assumed that if taken from PISA it must be a MM example. Further detailed descriptive analysis of the two problems showed that only 9% of all respondents knew Mathematical Modelling. Validity of this descriptive data of the responses according to two problems were checked by T-test. As a result, teachers who said that they know MM showed similar results as those who said that they don't know MM. Comparing means of this problems using a T-test showed that the average teachers choosing the MM PISA example as a MM-problem had a higher mean than non-MM apple example at a significant amount ($p=0.000$). However, it was found that both problems had a moderate statistical correlation. Correlation is statistical tool, which refers to the degree of linear relation (Croxtton, 1968). As it seen from table 1, the correlation between these two problems was a positive correlation of $r=0.431$, which means that teachers selected both questions as examples of MM modelling with the same periodicity. Moreover, correlation checks with other elements of MM showed that these had no correlation. For instance, in table 2 there was no correlation between "Collecting Data" and "Statistical Modelling". However, these are both elements of MM and there should have been a very strong correlation between them. Thus, it could be deduced that if teachers don't understand MM then how are they going to teach it to their students. Finally, the survey data using the two example questions was converted to a MM Score (does not know MM mean score=1.207 and know MM mean score-1.124). The analysis of these scores demonstrated that the majority of Kazakhstani teachers do not understand Mathematical Modelling. Subsequently one wonders how their students are to become active problem solvers on the PISA type questions in the Math literacy section of that exam.

5.3. Teachers' opinion about the use of Mathematical Modelling.

In figure 11a, it was seen that only 10% of respondents think that MM is not beneficial

in the class. Moreover, according to graph 11b it is clearly seen, that 60% of teachers would like to use Mathematical Modelling in their class. However, if we compare figures 13 and 14, one finds that there is a gap of 20% between those who think that MM is beneficial and those who would like to use in their class. Therefore, it may be deduced, that some teachers know that MM beneficial to use in the class, however due to some obstacles, they are not ready to use it in their classes. In the literature review it was mentioned by Galbraith & Stillman (2006) found that studying Mathematical Modelling is difficult for teachers and students due to the complexity of teaching. In this case the greatest struggle of might be that that teachers do not seem to know how to use MM. This is a double edged sword since as Ferri (2013) showed teachers who have the wrong understanding about MM, avoid using it in their classes. In addition, Ferri (2013) found that teachers thought MM required a lot of time and was too difficult to their children. The survey results of this study show similar results since the main fear of Kazakhstani teachers is that parents and students will not like MM. In SIAM report (2014), the majority of teachers wrongly believed that MM could involve unrealistic scenarios such as pattern blocks or tangrams, which means they thought that MM included the construction of different objects and shapes using geometrical shapes. For instance, in the survey teachers thought, that MM is a game, which in reality is wrong.

The results of this study show that teachers also had different beliefs and concerns regarding Mathematical Modelling. For instance, some teachers wrongly believed that problems concerning average speed or game format questions were examples of Mathematical Modelling. This result demonstrated the crucial role of that mathematics professional development could play in the secondary schools of Kazakhstan.

5.4. Professional Development on Mathematical Modelling.

It has been clearly shown that teachers are perceiving MM incorrectly or do not have correct knowledge about MM. In addition, the results of previous chapter showed, that

overall 70% of teachers agree, that they should teach less theory on Mathematics lessons. Therefore, from those two statements it may be concluded that they do not know how to implement application based mathematics in their classes. Moreover, the results of the survey showed that teachers are lacking Professional Development on Mathematical Problems (see figure 9). Therefore, there is a necessity to conduct special courses or workshops, which allow teachers to understand how to teach Mathematical Modelling to their students. However, not all PD on MM are effective. Courses on MM requires not only theory and beliefs of MM, but it requires teaching teachers to effectively incorporate MM in their lessons (Common Core State Standards Initiative, 2010, p. 7). They also should be taught how to create rubrics for assessments, how to design and integrate MM into curricular standards, and maximize efficient use of time (Pollak, 2012).

Gaston & Lawrence (2015) on their research came to following conclusion:

“...Professional development must ... help each in-service teacher in clearly defining Mathematical Modelling; actually developing, doing and assessing Mathematical Modelling activities; in learning not only appropriate pedagogical strategies but modern multidisciplinary content; and in successfully utilizing his/her academic background and professional expertise as unique resources to learn how to best facilitate Mathematical Modelling in the classroom.”

From the survey results, it was clearly seen, that those teachers, who thought they had attended PD on RLP or MM in reality did not have good understanding of MM. It is expected that PD on MM should support teachers during their whole career. However, professional development in Kazakhstan requires a lot of changes, according to Ayubayeva, et al (2014), as there is a lack of systematic approaches to training teachers. The findings of this survey support this finding since if teachers did attend MM PD it did not increase their knowledge of the subject. As result, I may conclude, that stakeholders who are responsible for the professional development of teacher's should consider these issues. Especially, it requires policy-makers, who create necessary regulations and system, to all for the improvement of

the teacher's training in Mathematical Modelling if we are to reach the air standards desired for Kazakhstani youth.

5.5. Conclusion

The result of the chapter 5.1. shows that following study matches with the demographics of the Kazakhstan. Teachers of Kazakhstan are not familiar with Mathematical Modelling. 5.2 sub-chapter discuss about familiarity of Mathematics teachers with MM. As a result teachers are not familiar with MM, moreover, they understand it wrongly. Similar pictures has among US teachers. NIS are more familiar with MM; however teachers of public schools are not. 5.3. sub-chapter shows that teachers of in general think that MM is complicated, and this tendency was explained in the studies of Galbraith, Stillman and Ferri. Finally in 5.4. sub-chapter it was explained the huge importance of PD in implementation of MM. PD should be implemented in complex form, and requires systematic regulations of policy-makers.

Chapter 6 Conclusion

6.1. Introduction

This chapter will review the final conclusions of the study, as well as present implications and limitations of the current study and recommendations for further research. The main question of this research is “What are the perceptions of mathematics teachers about using real-life situational problems, such as Mathematical Modelling in their classes?” In order to answer this question this chapter will focus on the two sub-questions:

1. “How do mathematics teachers understand the real-life situational problems such as Mathematical Modelling?” and
2. “What are teacher perceptions concerning the need to teach mathematics using authentic problems such as Mathematical Modelling, within their classes?”

6.2. Review of Findings

This section of the chapter is divided into three sub sections. Each sub section reviews the major findings of the study in terms of teachers' knowledge and perceptions of Mathematical Modelling as well as professional development focused on Mathematical Modelling.

6.2.1. Teachers knowledge of Mathematical Modelling

The research hypothesis was that most of the Mathematics teachers of Kazakhstan are not familiar with Mathematical Modelling. According to the survey results, only 9% of Mathematics teachers truly understand Mathematical Modelling. There are teachers, who think that Mathematical Modelling is a word problem, a mathematics game or a simple velocity problem. Therefore, in general, teachers' are not able to teach Mathematical Modelling due to lack of knowledge about MM; subsequently, they are not able to prepare students for solving Real Life Problems. This chain ultimately results in teachers not being

able to prepare students for international exams such as the PISA examination, which focus on Mathematical Modelling.

6.2.2. Teachers Professional Development in Mathematical Modelling

According to the survey, approximately 30% of the participants claim to have attended PD focused on MM and real life problem solving and 46% say they are familiar with MM. However, the survey also demonstrated that only 9% of the participants really had knowledge of MM problems. This means that there is a large gap in in-service teacher preparation in terms of Mathematical Modelling. In addition, 64% of participants think that pedagogical institutes prepare their students (i.e., future mathematics teachers) to teach Mathematical Modelling in their future classes. This is disturbing since 91% of the survey participants were not taught about MM in either their own pedagogical institutes or professional development courses. As a result, teachers across Kazakhstan require high quality PD focused on MM. In addition, for the long term, it is necessary to implement teaching of MM in pedagogical institutes. According to Lawrence and Gaston (2015), PD on MM should train teachers from different perspectives, such as organizing the class, creating problems and assessing problem solutions. NIS schools had the largest percentage of teachers (40%) out of the 9%, who were able to correctly answer the MM problem statements on the survey. Perhaps these results are due to having experienced the largest amount of Professional Developments and teacher training (Shamshiddinova, et al, 2013). Therefore, NIS teachers are more experienced with these types of problems. However, overall NIS mathematics teachers still have limited knowledge of MM. BIL and Mainstream schools' are the least knowledgeable about MM; but they also had the least number of PD on MM. Therefore, not only these schools but all schools in Kazakhstan require a large number of high quality PD in order to be able to teach teachers how to use application problems in Mathematics lessons. Moreover, the survey also found that in general teachers are having very few PDs at the school level. Therefore, a

Comment [A]: I would have expected more in-depth analysis of this knowledge gap in teachers and link it to other issues associated with it and then draw a conclusion –a bold statement about how teachers' insufficient knowledge (both content and pedagogical knowledge) affects their teaching and students' learning...ultimately the quality of education and human resource in the country.

majority of schools' do not have a culture of development inside their schools. It is recommended to implement high-quality professional development both inside the school as well as outside the school at a regional level.

6.2.3. Teacher's perception of MM

Overall teachers agree, that they should not teach mathematics from only a theoretical perspective and that it would be beneficial to teach Mathematical Modelling in their classes. However, they think, that there are obstacles, which make teaching MM complicated. The main fear of teachers' is the lack of curriculum and textbooks. However, in Kazakhstan curriculum and textbooks are centralized and being created (controlled) by Ministry of Education and Science. Therefore, implementation of MM in secondary schools depends on MoES. As a result, it is recommended for policymakers push for more MM classroom examples be included in textbooks and curriculum.

Further results illustrate, that teachers tend to think, that parents and students are against MM. They believe that one of the reasons for this is that math lessons may become unpredictable if MM is utilized. Lesh, et al, in their work (2013) claims, that using Mathematical Modelling made students more self-regulated and prepared for real-life. In other words, MM teachers need to teach students how to catch the fish, rather than giving students already prepared fish. Therefore, it is recommended for governmental organizations to develop special conditions and regulations to implement MM in the secondary schools of Kazakhstan.

6.3. Limitations of this study and further research

The main limitation of this study is that the survey used only two examples of math problems in order to identify teachers' ability to recognize MM questions. Two questions did not allow for a direct assessment of significance in this study due to guessing. In addition, a limitation which pertains to this is that the MM example used was taken from PISA and cited

that fact. This I believe caused a greater number of teachers to choose the MM question as an example of Mathematical Modelling for the reason that they simply thought the MM example would be a PISA question.

According to SIAM (2014) teachers with little experience in MM in the US tend to think, that MM requires a lot of time on assessments, reflection and lesson creation.

Unfortunately, due to time constraints the survey of this study did not ask about these issues, subsequently it did not allow for the determination if Kazakhstani teachers concurred with these findings.

This study had participants only from the three largest populated areas of the country. It would have been better to be able to have participants from the western areas as well as rural areas of the country to determine the issues in those parts of Kazakhstan. However, due to the results of this study it is felt that the results of such a study would be similar since the teachers in the more urban areas would be expected to have more access to training than those in rural or outlying areas of the country.

6.4. Recommendations for Future Study

This topic would benefit from the development of a more rigorous set of questions that would allow for a straightforward assessment of teacher knowledge about Mathematical Modelling. Moreover, analysis on RLP among teachers of Kazakhstan will benefit policy makers and school administrators. It will show, what factors should be taken into account before implementation of MM in the secondary schools. In addition, it would be good to create a survey that would be used in more than one country for comparison of teacher knowledge and perception of MM across countries. This type of study could allow for more efficient curriculum development and testing of PD models to alleviate the training gap in order to more quickly support our future citizens.

Finally, the study requires qualitative research in this area. The survey in this study only allowed for the determination of major factors that are barriers to the use of MM in classrooms. Interviews would allow for a richer determination about how these factors specifically affect teachers' ability to teach using Mathematical Modelling.

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Appendix A

Survey

Select language. Выберите язык/Тілді таңдаңыз/Choose the language

- Русский (1)
- Қазақ тілі (2)
- English (3)

Dear teacher, You are invited to participate in a survey lasting about 20 minutes. The purpose of this study is to determine how teachers of mathematics use mathematical problems in real life, in particular, the use of mathematical modeling in their classes. The study does not intend to evaluate the success of using mathematical modeling and does not evaluate the knowledge of teachers about the ability to use real situational problems. I collect data to complete my master's degree in school education and leadership. The risks of this study are minimal for you since your participation in the study will not have any consequences or negative consequences for your work. The risk is a possible loss of confidentiality, but the survey is anonymous. The main advantage for you is the opportunity to share your teaching experience, and the results of the questionnaire will help in identifying the effectiveness of mathematical modeling in schools. In addition, the results of this study will determine how the solution of mathematical problems in real life helps teachers of mathematics. The participants of this survey have the opportunity to participate in the lottery to receive a certificate of TechnoDom in the amount of 10 000 tenges. To do this, at the end of the survey you will need to leave your contact phone number. All data will be de-identified. Thank you for reviewing my survey. Best wishes, Master student of Nazarbayev University, Akhmetbekov Rasul Aubakirovich.

- I am agreeing to take a survey (1)
- I am not agreeing to take a survey (2)

Questionnaire

1) Are you teacher of Mathematics?

- Yes (1)
- No (2)

2) Show your gender

- Male (1)
- Female (2)

3) Which age category are you in?

- 20-24 (1)

- 25-29 (2)
- 30-34 (3)
- 35-39 (4)
- 40-44 (5)
- 45-49 (6)
- 50-54 (7)
- 55-59 (8)
- 60-64 (9)
- 65-70 (10)

4) What is your teaching experience?

- 1-3 years (1)
- 4-6 years (2)
- 7-9 years (3)
- 10-12 years (4)
- 13-15 years (5)
- 16-18 years (6)
- 19-21 years (7)
- 22-24 years (8)
- 25 years and more (9)

5) What is your educational level?

- High (1)
- VET (2)
- Middle education (3)
- Basic education (4)

6) Do you have educational degree?

Yes (1)

No (2)

7) In which region of Kazakhstan do you live?

Astana (1)

Almaty (2)

Aqmola region (3)

Aqtobe region (4)

Almaty region (5)

Atyrau region (6)

East-Kazakhstan region (7)

Zhambyl region (8)

West-Kazakhstan region (9)

Karagandy region (10)

Kostanay region (11)

Kyzylorda region (12)

Mangystau region (13)

Pavlodar region (14)

North-Kazakhstan region (15)

Turkestan region (16)

South-Kazakhstan region (17)

8) What language do you teach? (If necessary, select several)

Kazakh (1)

Russian (2)

English (3)

other (4)

9) Choose the type of school you work for?

Comprehensive school (1)

NIS (2)

BIL (3)

Daryn (4)

Private (5)

Gymnasium (6)

Lyceum (7)

Specialized school (8)

Other (9)

10) Do you have experience in NIS school?

Yes (1)

No (2)

11) Basically what classes do you teach?

1 to 4 (1)

4 to 6 (2)

7 to 9 (3)

10 to 12 (4)

12) Have you attended any professional development courses?

Not (1)

School (2)

Urban (3)

State (4)

International (5)

Answer the questions. The order of answers from positive to negative.	Completely agree (YES) (4)	Partially agree (More YES, than NO) (3)	Partially disagree (More NO, than YES) (2)	Completely disagree (NO) (1)	I do not know (0)
Do you attend any professional development on Mathematical Modelling? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Are you familiar with PISA typed questions? (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Have you attend any professional development on problems concerning Real life situations? (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Are you familiar with Mathematical Modelling? (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Are you familiar with Statistical Modelling? (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Are you familiar with Pearson's r value? (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Can collecting data be a part of Mathematical Modelling? (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13) In your opinion, which option is an example of Mathematical Modeling (MM)? (you can choose several options)

- Real life problem (1)
- Word problems (2)
- Games (3)
- Data collection (4)
- Data analysis data transfer to mathematics (5)
- Task with speed (6)

My answer (7)

14) "Askar had five apples. Two apples were eaten by Samal, how many apples Askar have now?". Is this a Mathematical Modelling question?

Completely agree (4)

Partially agree (3)

Partially disagree (2)

Completely disagree (1)

I do not know (0)

15) This is the question taken from the PISA exam. Do you think is it MM?:

"Jean assumes the colony will continue to grow in the following manner:

1) At the beginning of each year, the colony consists of equal numbers of male and female penguins who form couples.

2) Each penguin couple raises one chick in the spring of each year.

3) By the end of each year 20% of all the penguins (adults and chicks) will die.

4) One year old penguins will also raise chicks.

Based on the above assumptions, which of the following formulae describes the total number of penguins, P , after 7 years?"

Do you think this is an example of mathematical modeling?

Completely agree (4)

Partially agree (3)

Partially disagree (2)

Completely disagree (1)

I do not know (0)

16) The question about Askar and apples is not a matter of Mathematical Modeling (MM). The question about penguins is an example of MM. According to Lesh and Doer (2003): "Mathematical modeling is a process of mathematization, interpretation, verification, revision and generalization of real situations or complex systems." This includes data collection from real life, its analysis and synthesis.

	Completely agree (YES) (4)	Partially agree (More YES, than NO) (3)	Partially disagree (More NO, than YES) (2)	Completely disagree (NO) (1)	I do not know (0)
Is it beneficial to use Mathematical model in the class? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Mathematics should be taught only theoretically (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Parents are against new approaches, such as mathematical modelling in teaching mathematics (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Students are against new approaches, such as mathematical modelling in teaching mathematics (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
School administration are against new approaches, such as mathematical modelling in teaching mathematics (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The general conditions in my school make it difficult to teach MM. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It requires special textbooks to teach mathematical modelling in the school (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It requires special curriculum to teach mathematical modelling in the school (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17)

Completely agree (YES) (4)	Partially agree (More yes, than NO) (3)	Partially disagree (More NO, than YES) (2)	Completely disagree (NO) (1)	I don't know (0)
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I don't know where to obtain such tasks (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Assessing pupil performance on such tasks is	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

complex (2)

Through use of MM , the lesson will become unpredictable (3)

I like to use MM in my class. (4)

It requires a lot of time to plan MM tasks (5)

Students don't know how to transfer real life into mathematics (6)

Students don't know what they are supposed to do in doing MM (7)

Students act negatively, when doing such tasks (8)

MM fosters students to work independently (9)

Modelling task fosters understanding equally well for both high and low achieving students (10)

Students strongly identify the connection between reality and Mathematics after MM task (11)

Do pedagogical institutes teach authentic mathematical modelling? (12)

18) What are the obstacles to using real-life problems in a math lesson? (you can choose several options)

Time consuming (1)

Not all models are suitable for every student. (2)

Perceived as a game (3)

Resource complexity (4)

Not every topic can be explained with modeling. (5)

I don't know (6)

My answer (7)

19) Why do you think mathematical modeling is useful? (you can choose several options)

Learning, seeing and touching (1)

Permanent training (2)

Interesting (3)

Facilitate the work of the teacher (4)

To teach the subject faster (5)

Memorized by students (6)

Logical thinking develops (7)

Conceptual understanding (8)

Promotes understanding (9)

None of the answers (10)

My answer (11)

20) What do you think we should do to improve PISA results? (Your option)

21) If necessary, will you have the opportunity to have an interview with me on Mathematical Modeling? If yes, please write contacts.

Yes (1) _____

No (2)

22) If you wish to participate in the lottery for a certificate from Tekhnodom for 10,000 tenge, then please write your phone number in an empty window.