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Preservice teachers' beliefs towards mathematics and mathematical modelling in modelling processes

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Abstract

The aim of this study is to investigate pre-service mathematics teachers' beliefs towards mathematics and modelling in mathematical modelling processes. To achieve this aim, a phenomenology design was utilized. The study was conducted with 30 elementary level pre-service mathematics teachers receiving mathematical modelling courses. A semi-structured interview form was used to explore teachers' beliefs. At the end of the study, it was seen that mathematical modelling applications caused an increase of application-oriented beliefs. It was also observed that pre-service teachers who had schema and formalism-oriented beliefs evaluated mathematical modelling practices as time consuming and incomprehensible. Findings imply that modelling applications should be included in all levels of mathematics instructional curricula, in addition to the undergraduate curriculum.

Keywords: Beliefs towards modelling; mathematical belief; mathematical modelling; pre-service mathematics teachers

1. Introduction

Mathematical modelling is a general term covering real-life, open-ended and applied problem-solving practices at all levels of education (Erbaş, et al., 2014). Mathematical modelling is deemed significant in that it helps students to achieve basic mathematical goals such as understanding and mastering problems encountered in daily life (Kaiser, 2006). It is considered important to promote mathematical modelling in schools and within teacher education in major parts of the world (Borromeo Ferri, 2013). However, when the studies conducted on modelling are examined, it is seen that although many instructional materials have been designed in recent years, modelling played only a minor role in mathematics teaching (Blum & Borromeo Ferri, 2009; Doerr & English,

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2003; Zawojewski, 2010). When the literature is examined, it is seen those studies using the mathematical modelling activities examined the change of the affective characteristics such as anxiety, attitudes and beliefs or perceptions. In these studies, the effect of mathematical modelling activities on the perception of a mathematical concept such as integral, derivative or numbers (Ergene & Özdemir, 2020; Işık, 2016; Park et al., 2013), on mathematical attitudes (Kal, 2013; Kandemir, 2011; Wethall, 2011), on math anxiety (Kandemir, 2011; Santos, Belecina, & Diaz, 2015), on beliefs towards the teaching and learning of mathematics (Deniz & Akgün, 2018) and on beliefs about mathematics (Erol, 2015; Kaiser & Maaß, 2007; Shahbari, 2018) were investigated. Unfortunately, mathematical modelling in schools may not be integrated at the desired level due to various reasons including teachers' curriculum anxiety, unfamiliarity with mathematical modelling (Yu & Chang, 2011), difficulty in modelling after teaching for a while with routine problems (Deniz, 2014), and inappropriate beliefs about mathematics (Kaiser & Maaß, 2007). Considering that professional knowledge and beliefs are more likely to change during teacher education (Stillman & Brown 2011), and one of the obstacles in integrating mathematical modelling into schools is beliefs, this study aims to investigate the pre-service mathematics teachers' beliefs about mathematics and their beliefs towards mathematical modelling in modelling process.

1.1. Theoretical framework

The mathematical modelling approach is based on the mathematicalization of realistic situations that are meaningful to the learner (Wessels, 2006). Mathematical modelling can also be depicted as a procedure for giving information on any issue, understanding, painting, and light from mathematics (Bora & Ahmed, 2019). In mathematical modelling applications, these applications are definitely suitable for encouraging students to apply, appreciate, understand and love mathematics, as students can be included in the process of exploring and creating mathematics to apply it to reality, and as a result, students can grow quickly in terms of knowledge, capacity and disposition (Li, 2013). Modelling problems are designed for small group work that solves a complex situation of group members, and in these studies many questions, problems, conflicts, reviews, and decisions arise as students prepare to develop, evaluate, and communicate their models (English & Sriraman, 2009). Additionally, during this collective engagement, students are drawn into the reasoning of each other's understanding of the nature of modelling, their conceptions of mathematics, and their confidence in their mathematical knowledge and the ability to use it (Brown & Stillman, 2017). The teaching and learning of mathematical modelling have been an important research field around the world in recent years (Schukajlow, Kaiser & Stillman, 2018). However, due to teachers' inappropriate approaches to modelling activities, it is still not implemented at the desired level in schools (Borromeo Ferri & Blum, 2013). One of the reasons for this situation is that beliefs in mathematics teaching prevent the wide application of realistic tasks. Teachers' approaches to modelling may be due to their belief in mathematics (Kaiser & Maaß, 2007). Therefore, integrating the mathematical modelling into mathematics teaching should have beliefs that will help future teachers to use this new teaching approach.

There is not a definition of belief accepted by everybody. However, according to Eleftherios and Theodosios (2007), a belief is the personal knowledge, theory and concept that appear in a subjective manner. From a mathematics perspective, beliefs are the primary regulators for professional behaviors of mathematics teachers, leading to different teaching practices among educators. Therefore, beliefs in mathematics influence the beliefs in teaching and learning it (Ernest, 1989, 1991). In other words, beliefs in mathematics and mathematics teaching control the pedagogical behaviors of teachers strongly (Kaiser & Maaß, 2007; Rozelle & Wilson, 2012). In the literature, mathematical belief systems are classified in different ways. For example, Ernest (1989) classified these beliefs as problem-solving, Platonist and instrumentalist beliefs. Grigutsch, Raatz and Törner (1998) classified the mathematical belief systems under four headings; these are understanding mathematics as a science which consists of problem-solving processes (aspect of process); understanding mathematics as a science related to society and life (aspect of application); understanding mathematics as an absolute, formal and logical science (aspect of formalism); and understanding mathematics as a collection of rules and formulas (aspect of scheme). The first two views are accepted as dynamic beliefs while the last two are accepted as static beliefs (Grigutsch et. al., 1998). The classification of Grigutsch et al. (1998) is similar to that of Ernest (1989) in that the problem-solving approach to belief is similar to the process aspects of Grigutsch et al. (1998).

Maaß (2005) considers the classification made by Grigutsch et. al. (1998) as a subject-based belief categorization. She claimed that subject-based beliefs did not define mathematical belief systems adequately because many students did not have an idea of how to characterize mathematics, and that their ideas were mostly related to the classes and their roles in these classes. Therefore, such beliefs are defined as non-subject-based beliefs (Maaß, 2005). Maaß (2005) classified non-subject-based beliefs as cognitive shaped and affective shaped as shown in Table 1.

Table 1. Reconstructed of non- subject-based beliefs by Maaß (2005)

Cognitive shaped non-subject-based beliefs (beliefs of cognitive priority)	
Beliefs about the short duration of teaching units within the maths classes.	Teaching units should be short and that maths classes should consist of a lot of short exercises to work on.
Beliefs about a minor importance of words in the exercises.	The belief that writing is not important for mathematics courses. This belief was closely linked to the belief that mathematics is characterized by numbers and calculations and shows a fundamental negative view of writing.
Beliefs about the necessity of learning.	The belief that one could cope with mathematics or not. As a result, dealing with mathematics should not consume labor.
Affective shaped non subject-based beliefs (beliefs with affective priority)	
Beliefs about the teaching methods	Teaching methods are of great importance; for example, students like math classes because they are allowed to work in groups.
Beliefs about the atmosphere within maths classes	A friendly atmosphere is very important for these students.
Beliefs about understanding	Understanding mathematical content greatly affects students (when the students understand the content, they like the lessons and when they don't understand the content, they hate it).

Maaß (2005) found that one subject-based or non-subject-based aspect turned out to be the most important and she tried to define the relationship between mathematical belief system and students' behaviors with six ideals (Table 2). According to Maaß (2005); the students with Ideal type A have an application-oriented mathematical belief system and regard the modelling examples positively; the students with Ideal type B have a process-oriented mathematical belief system and a positive attitude towards modelling examples; the students with Ideal type C have a scheme-oriented mathematical belief system and reject the modelling examples in an emotional way; the students with Ideal type D have a formalism-oriented mathematical belief system and reject the modelling examples in an emotional way; the students with Ideal type E have a cognitive shaped non subject-based mathematical belief system, including beliefs about short-lasting teaching units, minor importance of texts and little necessity of learning and they react in a negative manner towards modelling examples; the students with Ideal type F have an affective shaped non subject-based mathematical belief system, including beliefs on teaching methods, atmosphere and understanding, and the students believe that they understand the content well. They regard the modelling examples as positive and develop application-orientated beliefs.

Table 2. Relationship between mathematical belief system and students' behaviors with six ideal types Maaß (2005)

Ideal types	Mathematical belief systems
Ideal Type A	An application-oriented mathematical belief
Ideal Type B	A process-oriented mathematical belief
Ideal Type C	A scheme-oriented mathematical belief
Ideal Type D	A formalism-oriented mathematical belief
Ideal Type E	A cognitive shaped non subject-based mathematical belief system
Ideal Type F	An affective shaped non subject-based mathematical belief

When studies examining mathematical models and beliefs about modelling are examined, it can be seen that Ramirez (2017) classifies teachers' beliefs about mathematical modelling into three dimensions; 1) mathematics in itself, in particular considering mathematical models and modelling; 2) beliefs about learning and teaching mathematics modelling (considering students, behaviors, lesson planning, and task design); and 3) real-life past experience with mathematical modelling. Ärlebäck (2009) examined the beliefs of mathematical models and modelling, not beliefs in teaching and learning of mathematical models and modelling. Ärlebäck (2009) suggested that the structure of the beliefs of teachers in mathematical models and modelling should consist of the beliefs about the nature of mathematics, real world, problem solving, school mathematics and applying, and applications of mathematics.

As seen above, there are different classifications of beliefs about mathematics, about teaching and learning mathematics, about mathematical models, and modelling. Many researchers study mathematical beliefs as well as the beliefs in certain areas of mathematics (i.e., mathematical modelling) because mathematical modelling is part of mathematics (Ramirez, 2017).

Beliefs stem from the experiences (Mutodi & Ngirande, 2014) and it is difficult and slow to change beliefs (Ambrose, 2004; Kaiser & Maaß, 2007; Viholainen, Asikainen & Hirvonen 2014). When the possible connections between beliefs and learning processes are considered, the search for methods to change beliefs is an unsolved problem (Kaiser & Maaß, 2007); and the question of how beliefs of teachers in teaching and learning mathematics are related with applications is an active research area (Ärlebäck, 2009). Teachers have a wide influence on students' construction of their beliefs (Pehkonen & Törner, 1996). So, it can be said that the starting point of changing students' mathematical beliefs is teachers' beliefs (Mason & Scrivani, 2004). However, teachers' beliefs are shaped through the experiences in learning mathematics during their student years, and the experiences in teacher education process during their university years; in other words, it depends on their history and their experiences (Handal, 2003; Mutodi & Ngirande, 2014; Philipp, 2007; Ramirez, 2017). Thus, the beliefs of pre-service mathematics teachers in mathematics and modelling may affect their teaching activities when they become teachers in the future. If beliefs are considered as the filters influencing the practices of teachers, and if mathematical modelling is to be included more in mathematics teaching, it is important to examine the beliefs in mathematical modelling and mathematics (Ärlebäck, 2009).

1.2. Aim and research questions

By determining the mathematical beliefs of pre-service teachers who will apply mathematical modelling in their courses in the future and how their beliefs about modelling change, it can contribute to the integration of mathematics courses with the modelling method. In this respect, the aim of this study is to determine the pre-service mathematics teachers' beliefs about mathematics and their beliefs towards mathematical modelling in modelling process. In order to achieve this aim, the following research questions were designed:

(i) How did pre-service mathematics teacher's mathematical beliefs change in mathematical modelling processes?

(ii) How did the pre-service mathematics teachers' beliefs towards mathematical modelling change in mathematical modelling processes?

2. Method

2.1. Study design

In this study, the Phenomenology Design, which is one of the Qualitative Research Methods, was used to determine the beliefs of pre-service mathematics teachers in mathematics and modelling during mathematical modelling application process. In this design, the focus is on how people perceive, describe, judge, remember, feel, how they make sense of, and how they speak experiences (Patton, 2002/2014). It is important to reveal experiences in phenomenon science, the environment in which experiences pass, and the phenomenon under investigation (Metin, 2014) often because exploring the basic structures of experiences are desirable in scientific research (Merriam, 2013). The reason for using this approach in this study is that phenomenology may help to examine in depth the beliefs and experiences of individuals who participated in mathematical modelling activities for a period and, therefore, could express or reflect on their thoughts about the process of participation.

2.2. Participants

The study was conducted with 30 elementary school pre-service mathematics teachers, who were senior students and received "Mathematical Modelling" courses at a university in Turkey. The reason why pre-service teachers were chosen among the senior students was that they were sufficiently knowledgeable about math because they had taken many mathematics courses in their undergraduate education, but they had no experience of teaching. The convenience sampling method, which is one of the purposeful sampling methods, was used in determining who the participants will be. To keep the identity of the participants confidential, their names were coded as T1, T2, …, T30.

2.3. Data collection

Beliefs are not observable, but subtracted from observations, responses to interviews or questionnaires (Pepin & Roesken-Winter 2015). Therefore, in this study, the semi-structured interview form was used as the data collection tool to determine the mathematical beliefs of pre-service mathematics teachers and their beliefs in modelling during modelling process. The interview questions were prepared by the researchers by making use of the interview questions reported in the studies conducted by Ärlebäck (2009), Maaß (2005), Kaiser and Maaß (2007) and Ramirez (2017), who tried to determine the mathematical beliefs of pre-service mathematics teachers and their beliefs in modelling during modelling process. A draft form consisting of 12 questions was created when the first interview form was designed. To determine the convenience of the interview form, a pilot study was conducted with six pre-service mathematics teachers; and as a result of this pilot study, the form was re-organized to give its latest shape consisting of 4 questions instead of 12 questions. The reason for this was because some items in the draft form did not yield sufficient responses, or repetitive answers were received. To explain these questions, the first question in the interview form is about how their understanding has changed about mathematics. The second question is about how their understanding has changed about the importance of mathematics subjects taught at school. Because the consistency between beliefs about the nature of mathematics and beliefs about the subject mathematics taught at schools are of varying magnitudes (Thompson, 1992). The third question is about the evaluation of modelling applications according to their advantages and disadvantages. The last question is about how participants imagine mathematical modelling lessons in order to get suggestions.

In this study, pre-service mathematics teachers, who were studying at the 4th grade of mathematics department, received modelling training in the context of mathematical modelling courses for three hours per week during one semester. In these classes, pre-service mathematics teachers did not only have theoretical knowledge in mathematical modelling, but also tried to analyze modelling activities in group work and create their own modelling activities. During this modelling course, pre-service teachers were given necessary information about mathematical modelling and its types, mathematical modelling approaches and mathematical modelling process, the relationship between mathematical modelling and problem solving, and principles of model eliciting activities.

In the courses, mathematical modelling activities such as Big Foot Problem (Lesh & Doerr, 2003), Long Jump Problem (Doruk, 2010), Summer Jobs Problem (Lesh & Lehrer, 2000), Obesity Problem (Tekin Dede & Bukova Güzel, 2013) Greenhouse Effect Covering, Traffic Light, Population for England and Wales Problems (Berry & Houston, 1995) were applied. While selecting these activities, attention was paid to their conformity with Model Eliciting Activities, Design Principles and their representation of theoretical and experimental modelling types. Additionally, in these modelling activities, English activities were translated into Turkish and applied to language and mathematics field experts. In other activities, no changes were made. During the application process, the class order was arranged by the researchers to be suitable for the group working. During the data collection process, the participants were treated as comfortable as possible, no judgment was made about the data and the environment was not interfered with. While these activities are being implemented, a seating arrangement has been created in the classroom where pre-service teachers can easily communicate. After the activities were distributed, the participants worked individually for the first five minutes and then worked as a group. The reason for the participants to start individually is to first understand the problem situations in the activities and then to share their ideas in their groups. In this way, the pre-service mathematics teachers obtained theoretical knowledge in modelling, and acquired application skills. At the end of the semester, six prospective teachers were interviewed by employing the draft interview form which aimed to investigate the mathematical beliefs and the beliefs in modelling process. In the light of the data that were obtained, the draft form was revised, given its latest form, and finally, applied.

2.4. Data analysis

The data obtained from the interviews were analyzed using content analysis, which is a qualitative data analysis approach, by taking into consideration the classification, subject- based (aspect of application, process, scheme and formalism) and non subject-based beliefs (cognitive and affective shaped), suggested by Grigutsch et. al. (1998) and Maaß (2005). The reason for analyzing the pre-service teachers' beliefs considering these classifications is that they are still students, and they lack teaching experience in schools. The data obtained in the present study were transcribed firstly. An attempt was made to look for repetitive patterns when coding the data, and inappropriate data were removed from the coding. In coding the beliefs, a strong response to one of the codes was taken into consideration. Therefore, it cannot be concluded that a pre-service teacher had only one type of belief. The resulting orders came together to form a pattern. The category, code and frequency tables were created by the researchers independently, the common codes and categories were agreed upon, the different field experts were consulted in case of disagreement, the data was re-analyzed some time after the coding were made, the unnecessary codes were removed, and the tables created earlier.

2.5. Reliability and validity

To enhance trustworthiness of the research, data were analyzed by the researchers separately and codes were matched afterwards. While the codes and categories were created, the participants were contacted again to make sure that no incomprehensible and ambiguous explanations exist within the data analysis. Based on feedback from participants, the codes were reshaped and reorganized. The final form of the revised codes and categories was examined by a different field expert, and the codes and categories were finalized with feedbacks. In order to ensure the validity of the research, direct quotations from the participants regarding the codes and categories obtained in the findings section were used, and in order to ensure the reliability of the study, attention was paid to make sure that the results obtained were consistent with the data.

3. Results

3.1. The beliefs of pre-service teachers about mathematics

Pre-service teachers were asked how the mathematical modelling course led to a change in the nature of mathematics. When the answers given to this question were collected, the viewpoints of the teachers before and after the mathematical modelling courses were compared. The code, category and frequencies obtained from the beliefs of the pre-service mathematics teachers on the nature of mathematics before and after the mathematical modelling courses are given in Table 3.

Table 3. The beliefs and ideal types of pre-service mathematics teachers in the nature of mathematics

		Categories		Frequencies	
		Pre-service teachers' beliefs about the nature of mathematics before the mathematical modelling courses	Pre-service teachers' beliefs about the nature of mathematics after the mathematical modelling courses	f_{before}	f_{after}
Codes	Application-oriented (Ideal type A)	T2, T3	T1, T2, T3, T5, T6, T9, T16, T17, T18, T19, T21, T25, T29, T30	2	14
	Process-oriented (Ideal type B)		T4, T5, T7, T8, T11, T12, T18, T22, T23, T26, T27	0	11
	Scheme-oriented (Ideal type C)	T1, T2, T6, T7, T8, T9, T10, T14, T15, T17, T18, T20, T25, T28, T29, T30	T6, T13	16	2
	Formalism-oriented (Ideal type D)	T4, T5, T11, T12, T13, T15, T16, T19, T21, T22, T23, T24, T25, T26, T27	T8, T10, T14, T15, T20, T24, T28, T29	15	8

It is seen in Table 3 that the beliefs of pre-service teachers in the nature of mathematics were mostly scheme-oriented (Ideal type C) or formalism-oriented (Ideal type- D) or as a combination of them before mathematical modelling courses. It is also seen that pre-service teachers considered mathematics mostly as an aspect of process (Ideal type B) or an aspect of application (Ideal type A) or as a combination of them after the mathematical modelling courses. So, it can be said that the number of pre-service teachers characterized as Ideal types C and D decreased, on the contrary, it is seen that the number of pre-service teachers characterized as Ideal types A and B increased after modelling course.

The viewpoints of T9, who considered mathematics as numbers, symbols, rules and formulas before the mathematical modelling courses, or, in other words, had scheme-oriented belief (Ideal type C) in mathematics, are as follows:

> "*We thought of mathematics only as numbers, symbols, formulas and rules. I thought mathematics was just abstract concepts*."

The viewpoints of T9, who considered mathematics with scheme-oriented (Ideal type C) and thought that it was not as an applied-oriented before mathematical modelling courses, thought considered mathematics with application-oriented (Ideal type A) belief after the mathematical modelling courses, are as follows:

> *"After the modelling courses, I realized that mathematics is not only an abstract concept but a science that can be used in daily life."*

T10, considered mathematics as a set of rules and formulas, and an aspect of scheme-oriented (Ideal type C) before the mathematical modelling courses. However, he considered mathematics with a formalism-oriented belief (Ideal type D) or as a logical science after mathematical modelling courses. T10 also found modelling applications quite difficult. The following statement illustrates this case:

> *"I considered mathematics to be consisting only of numbers and symbols. I thought it consisted of certain rules without using too much logic. After the modelling lessons, I tried to make mathematics stand out from certain rules and use intelligence completely and separate from the rules. I started to think logically. But modelling applications were hard for me."*

It is seen that T10 considered mathematics as rules and formulas before the modelling courses and handled it as a logical science after modelling courses. Contrary to T10, one of the pre-service teachers who described mathematics with an aspect of formalism-oriented (Ideal type D) before the mathematical modelling courses, considered it with an aspect of scheme-oriented (Ideal type C) after the modelling courses. In other words, it was seen that this pre-service teacher who considered mathematics as a logical science with absolute results before the modelling courses, started to consider it with rules and formulas after the courses. The viewpoints of this teacher, T13, are as follows after the modelling courses:

> "*Mathematics was a logic-based lesson. Mathematics was a field that was solved in a logical way, and which had absolute results. Mathematical terms gained importance at the end of the course. We find our own formula in mathematics, which makes us feel like a mathematician. But sometimes in applications, it's too hard because it's really hard to create a formula."*

T19, considered mathematics as a definite, formal and logical science, and an aspect of formalism-oriented belief (Ideal type D) before the mathematical modelling courses. However, she considered mathematics with an application-oriented belief (Ideal type A) after mathematical modelling courses. The following statement illustrates this case:

> *"Mathematics was a field that was logically solved and whose results were precise. Right now, I can associate, interpret and solve problems with daily life."*

T11, considered mathematics as a definite, formal and logical science, and an aspect of formalism-oriented belief (Ideal type D) before mathematical modelling courses. However, he considered mathematical modelling courses with a process-oriented belief (Ideal type B) after mathematical modelling courses, stated these:

> *"Mathematics was based on logic, and I didn't know much. I couldn't think of how the topics were interpreted and how we needed to link to question solutions. After the modelling courses, we tried to find different solutions for all the questions, we tried to simplify the issue and find different solutions according to their level of understanding."*

T7, considered mathematics as numbers, symbols, rules and formulas, and an aspect of scheme-oriented (Ideal type C) before the mathematical modelling courses. However, she considered mathematics with a problem- oriented belief (Ideal type B) due to the complex structure of the modelling problems. The following statement illustrates this case:

> *"Before I took the modelling course, I thought that mathematics was usually composed of numerical information and operations. After modelling courses, we realized that mathematics enables us to think about complex problems from different perspectives and find different solutions ways."*

3.2. The beliefs of pre-service teachers about mathematics taught in schools

In the present study, we also examined the effect of mathematical modelling courses on the beliefs of pre-service teachers in the nature of mathematics as well as their beliefs in the importance of understanding the mathematics subjects taught at schools. When the answers to the second question were collected, the aim was to compare the viewpoints of the pre-service teachers with their viewpoints before and after the mathematical modelling courses. In Table 4, the categories, codes and frequencies of the beliefs of pre-service teachers before and after the mathematical modelling courses are given.

Table 4. The beliefs and ideal types of mathematics pre-service teachers in why understanding school mathematics subjects is important

		Categories		Frequencies	
		Pre-service teachers' beliefs about the importance of the school mathematics before the mathematical modelling courses	Pre-service teachers' beliefs about the importance of the school mathematics after the mathematical modelling courses	f_{before}	f_{after}
Codes	Application-oriented (Ideal type A)	T2, T11, T12, T21, T27, T30	T2, T3, T12, T14, T16, T18, T19, T21, T22, T23, T24, T25, T26, T27, T29, T30	6	16
	Process-oriented (Ideal type B)	T6, T22, T29	T5, T7, T13	3	3
	Scheme-oriented (Ideal type C)	T1, T3, T15, T16, T18, T19, T20, T23, T24, T25, T26, T28	T2, T15	12	2
	Formalism-oriented (Ideal type D)	T5, T7, T8, T9, T10	T1, T5, T8, T10, T11, T20, T23, T28	5	9
	Beliefs about a minor importance of words in the exercises (Ideal type E)	T4	T4, T6	1	2
	Beliefs about understanding (Ideal type F)	T13, T14, T17	T3, T8, T9, T13, T17, T18, T23, T24, T25	3	9

When the beliefs of pre-service teachers regarding the importance of understanding mathematics taught at schools before and after the mathematical modelling courses were examined it was seen that they had both subject-based and cognitive and affective shaped non subject-based beliefs. With the Beliefs about a minor importance of words in the exercises (Ideal type E) code, which belongs to cognitive shaped non subject-based beliefs, meant that understanding mathematics was not to deal with verbal expressions. With the beliefs about understanding code (Ideal type F), which belongs to the affective shaped beliefs, meant to love the mathematics course if the content is understood. It is seen that most of the participants characterized as Ideal type C before the modelling courses, and most of them characterized as Ideal type A after the modelling courses. It can be said that the number of pre-service teachers characterized as Ideal type C decreased, on the contrary, it is seen that the number of pre-service teachers characterized as Ideal types A, D, E and F increased after modelling course.

Before and after taking mathematical modelling courses, T27, who believed that understanding mathematics subjects was important in solving everyday life problems, in other words, who had application-oriented belief and Ideal type A, said:

> *"It was important that we could solve everything that we encountered in daily life with the topics that we covered in mathematics. After courses we saw that we could solve problems from everyday life thanks to mathematics."*

Before modelling courses, T22 thought that the mathematics subjects taught in schools are important for routine problem-solving processes, however, they are not sufficient for daily life. The opinions of T22 changed to application-oriented after modelling courses:

> *"Mathematics was important to solve problems and seek answers to questions. After modelling, we found that the aim of mathematics taught at school is not to bring students to a certain level but to teach them to recognize life. In mathematics classes, mathematics is based on daily life and makes sense of daily life."*

Before and after taking the mathematical modelling courses, T17, who believed that understanding mathematics subjects was important in terms of beliefs about understanding (Ideal type F) towards mathematics course and had affective shaped non subject-based belief, stated that:

> *"Understanding mathematics subjects means a lot of entertainment. Otherwise, it becomes a torture. It allows us to love the lesson and the field. It influences our viewpoint on lesson in a positive manner. This idea remained the same after modelling courses."*

Before taking the mathematical modelling courses, T4 had beliefs about a minor importance of words in the exercises in understanding mathematics subjects. However, after modelling courses, T4 stated that verbal expressions as well as rules and formulas were important in mathematics:

"Understanding mathematics means always dealing with numbers, and not dealing with verbal statements. It is important to make numerical operations with rules and formulas. In the modelling courses, I saw that we need to understand verbal expressions. I understood how important words were in mathematics. A wrong word, a wrong concept in mathematics causes that the problem is solved incorrectly."

It was seen that T26 thought that understanding mathematics subjects taught at school was important in terms of formulas and rules of mathematics, i.e., scheme-oriented (Ideal type C) belief. T26 stated that after mathematical modelling lessons, mathematics subjects taught at school were important for solving daily life problems as follows (Ideal type A):

"In the past, understanding school mathematics was useless, it seemed like a pile of formulas and rules. Now, I think of it as a lesson that is completely in daily life and that has direct counterpart covering the daily life directly."

When Table 4 is examined, it is seen that T26 thought that mathematics did not have any significance in terms of application because understanding mathematical subjects was important in terms of learning the formulas and rules before the mathematical modelling courses, her viewpoints changed completely after the modelling courses; and she thought that understanding mathematical subjects was important for the aspect of application.

T10, who had formalism-oriented (Ideal type D) belief claiming that mathematics is considered as an absolute, formal and logical science for understanding mathematics subjects before and after receiving the mathematical modelling courses, said:

"Because mathematics requires the use of intelligence. It creates an absolute judgment in reaching the goal in the solution of the problems and necessitates authentic thinking. We learned how to use mathematical intelligence, how to think logically, and how to speak mathematically with the modelling course. Although this is very useful, we faced many difficulties, sometimes we're tired too."

3.3. The beliefs of the pre-service mathematics teachers towards mathematical modelling

Pre-service teachers were asked to indicate how they found modelling applications as advantages and disadvantages. In Table 5, the categories, codes and frequencies of the pre-service teachers' beliefs towards the modelling applications are given.

Table 5. Beliefs towards the modelling applications (advantages- disadvantages)

		Categories		Frequencies	
		Advantages	Disadvantages	$f_{advanteges}$	$f_{disadvantages}$
Codes	Beliefs about the short duration of teaching units within the maths classes (Ideal type E)		T7, T9, T13, T22, T28, T29, T30	0	7
	Beliefs about the teaching methods (Ideal type F)	T1, T2, T3, T4, T5, T6, T7, T8, T12, T14, T16, T17, T18, T19, T22, T23, T25, T26, T29, T30	T15, T19, T20	20	3
	Beliefs about the atmosphere within maths classes (Ideal type F)	T3, T9, T12, T13, T18, T21, T23, T24, T27		9	0
	Beliefs about understanding (Ideal type F)	T4, T6, T7, T8, T11, T19, T25, T26, T30	T10	9	1

Looking at Table 5, it is seen that many pre-service teachers stated more advantageous aspects of mathematical modelling applications. It was seen that the pre-service teachers' beliefs about the advantageous aspects of the mathematical modelling applications had the affective shaped non-subject-based beliefs (Ideal type F), which consist of "beliefs about the teaching methods, beliefs about the atmosphere within mathematics classes, and beliefs about understanding". It was determined that beliefs, which were seen as disadvantages, were mostly cognitive-shaped non subject-based beliefs (Ideal type E), which consist "beliefs about the short duration of teaching units within the maths classes. It can be said that pre-service teachers who are characterized as Ideal type F found modelling applications more advantageous, whereas pre-service teachers who are characterized as Ideal type E found it less advantageous.

T23, who had beliefs about the atmosphere in maths classes that is affective shaped non subject-based (Ideal type F), said the more advantageous aspects of mathematical modelling applications courses as follows:

"It was a comfortable, natural, creative, free and collaborative environment. For the first time, we solved the questions comfortably without having to squeeze ourselves into finding the right result."

T20, who had negative beliefs about the teaching method due to the group work, in other words, who had affective shaped non subject-based belief (Ideal type F), said:

"Since we worked in groups, there were members who remained passive in working with the group. In the group, some people did a lot of work, and some worked hard.

In addition, when there were differences of opinion, we had difficulty in reconciliation.”

Looking at the explanations of T23 above, group work in modelling activities provides an environment where pre-service teachers can work comfortably, and the participants see this positively. However, according to T20, group work was seen as a negative method due to the imbalance of the distribution of duties within the groups. However, this situation was seen as negative due to the imbalance of the distribution of tasks in the groups according to T20.

Most of the pre-service teachers stated that they liked the lesson when they understood the content, and only one of them stated that he did not like the lesson because he did not understand the content. T4, who understood the content and liked the lessons (who characterized as Ideal type F), stated:

“Everyone was thinking about the problem and trying to understand it. Everybody was trying to establish a relationship between mathematics and problems in everyday life. We did a lot of research, online, books ... Different ideas emerged, and we tried to establish the relationship accordingly. We have seen that we can solve problems without giving rules and formulas.”

T10, who did not like the lessons because modelling problems were difficult and he did not understand the context (who characterized as Ideal type F), stated:

“The questions were difficult, so it was difficult to comment. We couldn't establish a relationship. We did not understand the content."

He stated that he found the T10's modelling questions difficult. This shows that there are also difficulties in making sense of modelling questions, interpretation and connection with the content and therefore stated that he does not like the lessons. On the contrary, it is seen that T4 does not have difficulty in interpreting and associating, as he understands the content in the modelling questions and therefore likes the lessons.

T28 thought that mathematical modelling activities took a lot of time and should be shorter. So, she had cognitive shaped non subject-based beliefs (Ideal type E), which consist of “Beliefs about the short duration of teaching units within the mathematics classes”. The thoughts of T28 are:

“It took us a long time to find a result. More exercise could be done in one lesson.”

Considering the above explanation, it can be said that modelling activities take too much time, creating a negative perception towards these activities. It is seen that some of the pre-service teachers (for instance T10, T15, T20 and T28 as seen in Table 3 and Table 4) who had scheme and formalism- oriented beliefs about the nature and the importance of the mathematics subjects taught at schools indicated disadvantageous aspects of mathematical modelling method.

3.4. Imaginations of the pre-service teachers about mathematical modelling courses

The pre-service teachers were asked how they imagined mathematical modelling courses to have recommendations for mathematical modelling courses. The codes and categories for the answers given by the pre-service teachers are given in Table 6.

Table 6. The mathematical modelling courses in the imaginations of the pre-service teachers

	Categories		Frequencies
		Imagined mathematical modelling courses	f
Codes	Application-oriented (Ideal type A)	T1, T2, T3, T4, T5, T6, T7, T9, T11, T12, T13, T22, T24, T27, T29, T30	16
	Process-oriented (Ideal type B)	T23	1
	Beliefs about a minor importance of words in the exercises (Ideal type E)	T8, T28	2
	Beliefs about the teaching methods (Ideal type F)	T10, T11, T14, T15, T16, T17, T18, T19, T20, T21, T25, T26, T27, T28, T30	15

The answers given by the pre-service teachers were coded as application-oriented belief (Ideal type A), beliefs about the teaching methods (Ideal type F), beliefs about a minor importance of words in the exercises (Ideal type E) and process-oriented belief (Ideal type B). In general, the imagines of pre-service teachers about modelling classes focus on application-based and teaching method. It was seen in Table 6 that none of pre-service teachers responded this question based on formalism or scheme-oriented beliefs.

T30, who had an application-oriented belief (Ideal type A) about how mathematical modelling courses were imagined, said:

> *"Extra-curricular activities may be included. We need to have an idea when we face a problem in our daily lives. In addition, a group medium should be created in general. Cooperation is very important."*

T8, who had beliefs about a minor importance of words in the exercises (Ideal type E), thought that numerical expressions should be given more space in modelling courses because he thought that verbal expressions make it difficult to understand the problem in mathematical modelling courses. T8 said about it:

> *"Presenting problems with numerical statements may help students understand the problem better. There were no numerical operations in some problems, there were only verbal statements. Since there were no numerical forms or symbols, I had difficulty in understanding and solving the problem."*

T23, who had process- oriented belief (Ideal type B), thought that the activities should be taught starting from easy ones towards difficult ones in mathematical modelling courses:

> *"Problems should be given in every lesson. The examples should start from easy ones towards difficult ones."*

T30, who had an application-oriented (Ideal type A) and had beliefs about the teaching methods (Ideal type F), stated that:

> *"Modelling courses were great because they helped us work as a group, get to know each other and come up with different ideas. I always want modelling lessons to be this way. In addition, out-of-class activities can be emphasized."*

Pre-service teachers stated that out-of-school activities should be emphasized in modelling classes and a path from easy to difficult should be followed.

4. Discussion

In this study, pre-service mathematics teachers' beliefs in nature of mathematics and beliefs towards modelling in mathematical modelling processes are given. Considering the results of the study, it is firstly seen that the number of pre-service teachers who had application-oriented beliefs was low before the mathematical modelling courses, there were no pre-service teachers who had process-oriented belief; however, after the mathematical modelling courses, the number of those who thought of mathematics as an application-oriented and process-oriented science increased. In this study, non subject-based beliefs about nature of mathematics were not found before and after modelling course. As a result, it can be said that mathematical modelling applications caused an increase of application and process-oriented beliefs, about the nature of mathematics. Based on this, we may also claim that pre-service teachers had static beliefs (formalism or scheme- oriented) in mathematics before the mathematical modelling courses, and they had dynamic beliefs (application-oriented) after mathematical modelling courses. In the same study conducted by Kaiser (2006) and Kaiser and Maaß (2007) to examine the mathematical beliefs of teachers towards applications and modelling tasks and found that the mathematics teachers initially had static beliefs in the nature of mathematics, and after mathematical modelling courses, they developed dynamic beliefs. It can be said that this is due to the applications of mathematical modelling, which plays a bridge role with real life. Pre-service teachers faced open-ended, complex and real-life context related problems with mathematical modelling applications, and these situations direct their beliefs towards mathematics to application and process-based beliefs.

When the views of pre-service teachers on the importance of the mathematics subjects taught at schools before and after mathematical modelling courses were examined, not only the aspects of subject-based beliefs emerged, but also the affective and cognitive shaped non subject-based beliefs emerged in this process. During the modelling courses, dynamic beliefs about the importance of mathematics subjects taught in schools increased while static beliefs showed little change. It was also found that there was an increase in all beliefs except scheme-oriented beliefs during modelling course.

Before mathematical modelling courses, it was seen that beliefs about the importance of the mathematics subjects taught at schools are more application-oriented and process-oriented than beliefs about nature of the mathematics. It is understood from this that they thought the nature of mathematics as a stack of formulas or logic before modelling courses, while about the importance of the mathematics subjects taught at schools is more application or process based. After modelling courses, both beliefs mostly based on application-oriented beliefs. The concentration of pre-service teachers on mathematical modelling has given them the ability to overcome the gap between mathematics and the real world, causing their application-oriented beliefs to become stronger. These results of beliefs also show that most of pre-service teachers saw the modelling examples positively after modelling courses and developed application-oriented beliefs. Because pre-service teachers who had formalism or scheme-oriented beliefs rejected modelling examples. But pre-service teachers with other belief systems had a positive approach towards modelling examples. The results obtained from pre-service teachers apart from Ideal type E belief system are in parallel with the results of the studies of the Kaiser and Maaß (2007), and Maaß (2005), because in their studies, students and mathematics teachers with Ideal type A, B or F belief systems regarded the modelling examples as positive, and with Ideal types C, D, and E belief systems rejected the modelling exercises. The only result that was not reconciled with this study was that pre-service teachers with Ideal type E belief system had a positive view of mathematical modelling after the courses, because they thought that verbal expressions were very important for mathematics. Thus, the negative reactions of pre-service teachers with scheme or formalism-oriented beliefs may prevent them from integrating modelling problems into their classroom when they become teachers. Because these pre-service teachers saw the modelling examples too hard and mathematics as very difficult and complex in mathematical modelling applications. Kaiser and Maaß (2007) in their work stated that students' beliefs might prevent a broad implementation of realistic tasks in everyday mathematics teaching. This is also valid for the pre-service teachers in this study. Because their beliefs will prevent their class practices.

In the results of the beliefs about the mathematical modelling applications, it is seen that participants who had scheme and formalism-oriented beliefs about nature and the importance of the mathematics subjects taught at schools indicated more disadvantages than that of other belief systems aspects of mathematical modelling method. This situation may result from pre-service teachers with scheme and formalism-oriented beliefs which find modelling activities difficult and not being able to establish their relationships in real life. This may cause them to consider mathematical modelling applications as time consuming and incomprehensible. In the Kaiser (2006) study; formalism and scheme-oriented beliefs create high obstacles for application and modelling problems in mathematics teaching, because the nature of contextual and applied problems is not compatible with these beliefs. The most negative belief is related to beliefs about the short duration of teaching units within the math classes. As a result, pre-service teachers who had belief about the teaching methods had more positive beliefs about modelling applications than other pre-service teachers.

When considering the beliefs in classroom atmosphere in mathematical modelling courses, it was observed that they had positive affective beliefs. This result shows that class environments, which are faced with non-traditional problems and tried to be solved with different strategies, have a positive effect on mathematical beliefs, as Mason and Scrivani (2004) said. When looked pre-service teachers who had positive affective beliefs in the classroom atmosphere, it is seen that they had mostly application or process-oriented beliefs about mathematics and about importance of the mathematics subjects taught at schools after modelling courses. Ramirez (2017) conducted a study and reported that the teachers who participated in his study expressed the classroom atmosphere in mathematical modelling practices as creative, interesting, encouraging to think, and caring for student participation. These results are in line with the results obtained from the study. Maaß (2005) and Kaiser and Maaß (2007) also examined the beliefs about the atmosphere in their studies. In the Kaiser and Maaß (2007) studies, students stated that the atmosphere of modelling courses was negative, while in Maaß (2005) study, students stated that there was a wonderful friendly atmosphere in the classroom, and this was very important for the student.

In this study, most of the pre-service teachers stated that group work was positive. But some of them stated that their group friends did not participate in the study, some of them were unfair because they worked hard and sometimes, they found it difficult to compromise in different solutions. Student beliefs can be affected by their peers (Wilkins & Ma, 2003), so it can be said that this situation was caused by peers' affecting beliefs.

When the pre-service teachers were asked how they imagined mathematical modelling courses, their responses were based on the classification of beliefs in mathematics. With this respect, it can be said that beliefs about modelling are shaped around beliefs about mathematics. The participants described the modelling courses they imagined, mostly taking into account the application-based beliefs and beliefs about teaching methods. None of pre-service teachers responded based on formalism or scheme-oriented beliefs. Even those who previously had formalism and scheme-based beliefs focused on application, processes or teaching methods in their imagined modelling courses instead of formula or logic. Besides these, none of them talked about mathematical models or the importance of mathematical modelling. This result is parallel to Ramirez's (2017) results. In Ramirez's study (2017), only one teacher mentioned a focus on models. Some pre-service teachers stated that numerical expressions should be used more than verbal expressions in problems. These pre-service teachers refused to solve the activities because there was too much text in mathematical modelling activities, and it was seen that they had formalism-oriented beliefs about the nature of mathematics. However, it should be known that, besides the basic mathematical competence, understanding words are also important factors that are necessary for performing certain steps of the modelling process (Mischo & Maaß, 2012).

5. Conclusions and implications

The pre-service teachers did not really think that there was a relation between mathematics and real life before mathematical modelling courses. At the end of the study, it can be said that mathematical modelling applications caused an increase of application-oriented beliefs. This shows that pre-service teachers' ability to connect between mathematics and real life has an impact on their mathematical beliefs in modelling applications where they encounter non-traditional, open-ended and complex problems. It is also seen that scheme and formalism- oriented beliefs and their inexperience's about modelling may prevent future modelling applications of pre-service teachers. When the pre-service teachers are in their senior years at university, their beliefs in mathematics stem mostly from their previous experiences. However, their perceptions of such an application before they became teachers caused some changes in their beliefs and their beliefs will affect school practices. Because performing well in modelling tasks depends not only on skill but also on will, therefore the role of beliefs that encourage mathematical modelling is so important (Mischo & Maaß, 2012). When pre-service teachers develop strong beliefs, they can be sure of their ability to become successful teachers after entering the field (Galligan et al., 2019). About this, Mischo and Maaß (2013) concluded that teacher beliefs had an increase in the students' modelling skills. From this point of view, we can say that the pre-service teachers' beliefs towards modelling shifted to application-oriented beliefs and positive perspectives on modelling will affect students' achievements when they become teachers.

In this study, it was seen that pre-service teachers' mathematical beliefs affected their beliefs towards mathematical modelling, and modelling practices also affected their mathematical beliefs. From now on, modelling applications should be included in the curriculum of all classes, not just in the undergraduate curriculum.

6. Limitation of the Study and Future Research

The limitations of this study were that the study lasted only one term and that only 30 prospective teachers' opinions were obtained. Therefore, major changes are not expected in this short time. In addition, there may be possible effects regarding mathematical beliefs such as mathematical environment, teaching practice courses, the videos they watch and so on. Therefore, the purpose of this study was only to examine the effect of mathematical modelling applications. Some other effects on mathematical beliefs have not been considered. The obtained results only represent a university in Turkey. Therefore, to generalize the results, in future studies, beliefs may be examined in mathematical modelling activities where teachers, pre-service teachers, and students come together in the long-term. In this study, only interviews were used as a data collection tool. For the results obtained in future studies to be more valid and reliable, they should be supported by different data collection tools. In future studies, the effects of the beliefs about mathematics and about mathematical modelling on mathematical modelling competencies may be investigated.

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