PRE-SERVICE TEACHERS' PLAUSIBILITY PERCEPTIONS OF GLOBAL CLIMATE CHANGE: THE ROLE OF COGNITIVE, BEHAVIORAL AND PERSONAL VARIABLES

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DECLARATION OF ORIGINALITY

I, Gaye Defne Ceyhan, certify that

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ABSTRACT

Pre-service Teachers' Plausibility Perceptions of Global Climate Change:

The Role of Cognitive, Behavioral and Personal Variables

The main purpose of this study was to examine the role of cognitive, behavioral and personal variables on pre-service teachers' plausibility perceptions of global climate change. The sample of the study was 199 senior pre-service teachers in a public university in Turkey. Five instruments were used to investigate the research questions. Firstly, the participants' plausibility perceptions of global climate change were investigated. Participants mostly found the items on evidence supporting the human link to global climate change and predictions about future impacts highly plausible. Secondly, the participants' understanding of global climate change was explored. Although the majority of the participants had an understanding of the human influence on the current climate change and some of the consequences that humans are going to face, the majority of the participants had some misconceptions. Thirdly, correlational analysis showed that there was a significant positive relationship between the participants' understanding and plausibility perceptions of global climate change. Lastly, the role of cognitive, behavioral and personal variables on plausibility was examined. The results revealed that understanding, degree of willingness to act and need for closure were predictors of plausibility perceptions of global climate change. In particular, understanding had the largest contribution in explaining the variance in plausibility perceptions of the participants. The findings of the current study provide insights for teacher education programs on climate change education.

ÖZET

Öğretmen Adaylarının Küresel İklim Değişikliği Akla Yatkınlık Algıları: Bilişsel, Davranışsal ve Kişisel Değişkenlerin Etkisi

Bu çalışmanın temel amacı, öğretmen adaylarının iklim değişikliğini akla yatkın bulmalarında bilişsel, davranışsal ve kişisel değişkenlerin rolünü incelemektir. Çalışmanın örneklemini Türkiye'de bir devlet üniversitesinde okuyan son sınıf öğretmen adayları oluşturmaktadır. Araştırma sorularını cevaplamak için beş farklı ölçek kullanılmıştır. İlk olarak katılımcıların ilkim değişikliğini akla yatkın bulma düzeyleri incelenmiştir. Katılımcıların çoğu iklim değişikliğine insan etkisi olduğunu ve gelecekteki etkileri ile ilgili ifadeleri fazlasıyla akla yatkın bulmuştur. İkinci olarak katılımcıların kavrayış düzeyleri araştırılmıştır. Katılımcıların çoğu insan kaynaklı iklim değişikliği ve sonuçlarından bazıları hakkında bir kavrayışa sahiptir. Ancak katılımcıların çoğunda kavram yanılgısı bulunmaktadır. Üçüncü olarak katılımcıların iklim değişikliğini akla yatkın bulmaları ile kavrayış düzeyleri arasındaki ilişki incelenmiştir ve istatistiksel olarak anlamlı, pozitif bir korelasyon bulunmuştur. Son olarak, iklim değişikliğini akla yatkın bulma konusunda bilişsel, davranışsal ve kişisel değişkenlerin rolü incelenmiştir. Analiz sonuçları kavrayış düzeyi, iklim değişikliğini önlemeye yönelik davranış geliştirmeye istekli olma ve düşünme ihtiyacının iklim değişikliğini akla yatkın bulmayı yordama konusunda tahmin unsurları olduğunu göstermiştir. Özellikle, kavrayış düzeylerinin katkısının en fazla olduğu bulunmuştur. Bu çalışmanın bulgularının iklim değişikliği eğitimi konusunda öğretmen yetiştirme programlarına öngörüde bulunması amaçlanmaktadır.

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Last but not least, I want to express how grateful I am to my dad. His patience and enthusiasm as a teacher and as a father were unique. His everlasting purpose was to see me as a strong and well-educated woman. I will always work hard not to disappoint him. Deep in my heart he will always be loved and missed every day.

Dedicated to the loving memory of my dad,

and to my beloved mum,

and my dearest sister

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LIST OF ABBREVIATIONS

CRKM: Cognitive Reconstruction of Knowledge Model

GCC: Global Climate Change

HICC: Human-induced climate change

HICCK: Knowledge of Human-induced climate change

IPCC: Intergovernmental Panel on Climate Change

PJCC: Plausibility Judgments in Conceptual Change

PPM: Plausibility Perceptions Measure

PST: Pre-service teacher

SSI: Socio-scientific issue

CHAPTER 1

INTRODUCTION

We live in an inter-connected world, which brings societal, regional and global challenges. One of the challenging issues that we all face is global climate change (GCC). A recent report on GCC revealed that "the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (Intergovernmental Panel on Climate Change (IPCC), 2013, p. 4). This current change is attributed to the human activities that introduce several serious potential threats to the world with environmental, social, and economic consequences (IPCC, 2014; Stern, 2007). Considering the human influence on the current climate, many social and scientific societies are announcing the urgency for action as a civil duty that needs to be addressed in citizenship education (The American Association for the Advancement of Science (AAAS), 2007).

Issues in citizenship education have four main features, which are as follows: belonging to the real world, having ethical considerations, being contemporary and being controversial (AAAS, 2007). In other words, citizenship education includes issues that occur in the present time, have an influence on people's lives, let people consider the principles of morality, and contain conflicting opinions. In addition, learning in citizenship education includes understanding the concepts and the relationships between conceptions, using skills like critical thinking and analyzing alternative explanations,

and making evaluations by considering values and dispositions (Hodson, 2003). Keeping these features in mind, GCC is one of the outstanding issues in citizenship education.

Citizenship education also aims at improving individuals' scientific literacy (Hodson, 2003). Being scientifically literate is defined as having a deeper understanding of scientific concepts and processes in order to make analytical evaluations and take enlightened decisions. In addition, the utilization of socially relevant scientific topics (known as socio-scientific issues (SSI)) plays a role in developing scientific literacy (Zeidler, Sadler, Simmons, & Howes, 2005). GCC is considered as a SSI and learning about GCC requires the comprehension of deep scientific understanding and provides an opportunity to learn about the way scientists construct knowledge with its complicated nature (Lombardi & Sinatra, 2012).

In order to be scientifically literate on climate-related issues, people need to have a conceptual understanding of climate (Bofferding & Kloser, 2014; Papadimitriou, 2004; Rye, Rubba, & Wiesenmayer, 1997). However, people have problems in understanding the complicated scientific knowledge about climate, lack understanding about the fundamental basis of climate, and have various misconceptions about GCC (e.g. Kilinc, Boyes, & Stanisstreet, 2008; Rye et al., 1997). One of the most effective ways to overcome misconceptions is conceptual change, where concepts, interrelated conceptions and cognitive structures change over a period of time (e.g. Pintrich, Marx, & Boyle, 1993).

Conceptual change has been studied in different fields like cognitive psychology, social psychology and science education (Dole & Sinatra, 1998). Although these fields focused on separate perspectives to create conceptual change, they all aimed at providing conceptual understanding to the learner. While learning complex issues like

GCC, one of the significant features of conceptual change is the development of reasoning, problem solving and critical evaluation. These features are attributed to plausibility in conceptual change (Dole & Sinatra, 1998). It can be asserted that being an enlightened citizenry necessitates making critical evaluation among alternative explanations and forming plausible perceptions.

Teachers, who play an essential role in the learning process, need to be knowledgeable citizens. Papadimitriou (2004) stated that teachers' perceptions and intended actions have an influence on their students' understanding and attitude. Keeping these in mind, senior pre-service teachers (PSTs) were chosen as the participants of this study. The present study not only revealed PSTs' plausibility perceptions and understanding of GCC, but also identified misconceptions about GCC, which need to be determined and diminished before PSTs become teachers. It is also worthwhile to investigate the factors that influence plausibility because increase in plausibility is crucial in strong conceptual change. Therefore the current study also investigated the relationship between plausibility perceptions and understanding of GCC, as well as which among cognitive, behavioral and personal variables have a proportion to predict plausibility. The next section is aimed at presenting the rationale of the study to reveal the logical reasons for conducting the current research.

1.1 Rationale of the study

The rationale of the current study was based on three main aspects. The first aspect focused on the subject of this study (i.e. GCC), which should be addressed in citizenship education. The second aspect focused on the criterion variable (i.e. plausibility), which may be important in the conceptual change process to overcome misconceptions. The

third aspect focused on the sample of this study (i.e. PSTs), who have a vital role in citizenship education and teaching the interdisciplinary nature of GCC. Figure 1 presents a visual representation of the rationale of the study.

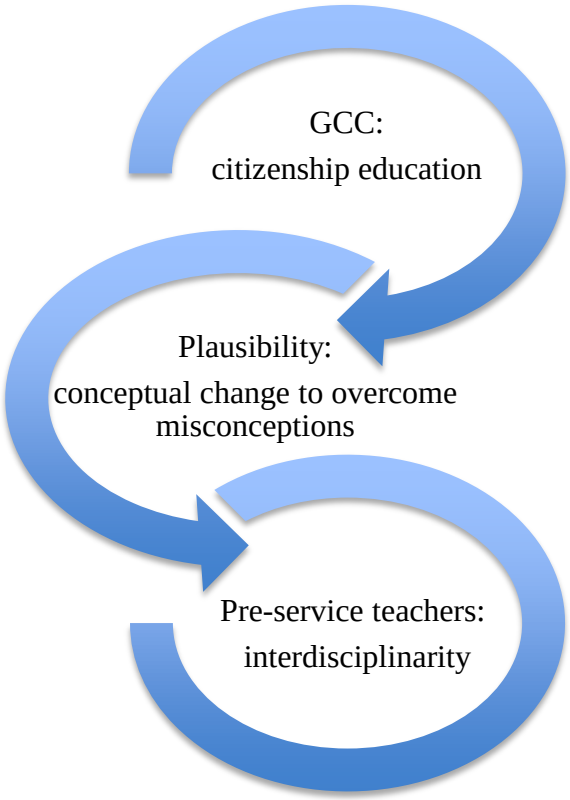


Figure 1 Rationale of the study

As shown in Figure 1, GCC was the first aspect in explaining the rationale of the current study. GCC was determined as the subject of this study because it is considered as one of the significant global issues in citizenship education. GCC brings regional and global threats to the world (IPCC, 2014). Banks (2001) stated that "a new kind of citizenship education, called multicultural citizenship, will enable students to acquire a delicate balance of cultural, national, and global identifications and to understand the

ways in which knowledge is constructed" (p. 5). According to this definition, effective citizens in today's world have cultural, national and global roles. In order to better establish these roles, there is a need for citizenship education.

Crucially, this study was conducted just after the release of the IPCC Fifth Assessment Report (2014). The report specifically stressed the human influence on current GCC, the projected impacts and risks caused by this change, the regional and global risks, and the likelihood of the decrease in these risks through certain adaptation and mitigation strategies. With the release of the IPCC (2014) report, there is an increased emphasis on becoming knowledgeable citizens concerning Earth's climate and climate related issues, "to become knowledge producers; and to participate in civic action to create a more humane nation and world" (Banks, 2001, p. 5).

GCC has complex scientific explanations and socially controversial arguments. Although GCC is a global issue for which every citizen needs to take responsibility, the rank of global warming and climate change among controversial topics was 29th out of 70 in Turkey's educational institutions (Yazici & Secgin, 2010). Therefore, it is important to examine people's understanding of GCC and overcome their misconceptions in order to design the necessary curriculum for their needs.

As seen in Figure 1, plausibility was the second aspect of the rationale of the current study. In order to overcome misconceptions, learners need to experience the conceptual change process (Posner et al., 1982). New concepts that aim to replace misconceptions should be plausible for learners to reconstruct knowledge throughout the learning process (Dole & Sinatra, 1998; Duit & Treagust, 2003). Furthermore, to create a strong conceptual change, plausibility has been addressed as a significant aspect in conceptual change models (Dole & Sinatra, 1998; Posner et al., 1982), particularly for

controversial issues where there may be a large gap between what lay persons and scientists find plausible (Lombardi et al., 2013). Connell and Keane (2006) also claimed that increase in complexity leads to a decrease in plausibility. As GCC is a complex SSI, it is important to determine (1) the level and (2) the factors that may have an influence on the learners' plausibility perceptions of GCC. Determining the level and influential factors of plausibility may be pivotal in creating conceptual change because a previous study has reported the empirical relationship between plausibility and conceptual change (Lombardi & Sinatra, 2012).

The third aspect of the rationale of this study was the participant (see Figure 1). Teachers play a vital role in the citizenship education and conceptual change process. This is because during the learning process of GCC teachers guide students to experience conceptual change. Research also suggest that teachers' understanding, their way of teaching and their classroom practices have roles in students' understanding (Brickhouse, 1990). However, having misconceptions about GCC is also common among teachers (e.g. Feierabend, Jokmin, & Eilks, 2010; Kalipci, Yener, & Ozkadif, 2009). As scientifically inaccurate ideas may be transferred to their students, teachers' understanding and misconceptions about GCC need to be determined.

Additionally, global citizenship requires being scientifically knowledgeable in order to comprehend and participate in discourse among global issues. GCC, as a multidisciplinary global citizenship topic, requires understanding in various disciplines and evaluating through different perspectives. For instance, the influence of temperature rise may be discussed in a chemistry course by inspecting changes in atmospheric composition; in a physics course by examining the atmospheric-physics models that presents additional greenhouse gases; in a mathematics course by calculating the carbon

dioxide release in a region at a certain amount of time; in an English course by reading articles to encourage learners to think about their attitudes; in preschool education by focusing on basic climate friendly actions. Therefore, teachers in different fields need to understand global climate and climate related issues.

Based on the above arguments, determining teachers' plausibility perceptions and understanding of GCC is important. Participants of this study were determined as PSTs from divergent fields who are going to be teachers of the future. Specifically, participants were studying in the fields of science education, mathematics education, preschool education and English education. With this rationale, the significance of the study is explained in the next section.

1.2 Significance of the study

The current study is significant in two main ways. Firstly, a number of studies have been conducted to examine PSTs' understanding and plausibility perceptions of GCC (e.g. Arslan, Cigdemoglu, & Moseley, 2012; Spellman, Field, & Sinclair, 2003; Lombardi, Seyranian, & Sinatra, 2014). However, as far as we know, this is the first study conducted in Turkey aimed at determining the level of PSTs' plausibility perceptions of GCC and exploring the relationship between understanding and plausibility. This study is believed to be useful for teacher educators and teacher education researchers on how to promote PSTs' understanding and plausibility perceptions of GCC. Additionally, determining PSTs' conceptions, perceptions and misconceptions is necessary in designing fruitful teacher education programs.

Secondly, findings of the research revealed that knowledge structures about GCC have an impact on learners' decisions and their personal actions (Bofferding & Kloser, 2014). Further, keeping the scientific nature and the social aspects of GCC in mind, individuals' disposition toward knowledge and epistemic motivations may have an influence on their plausible perceptions (Lombardi, Nussbaum, & Sinatra, 2016). Therefore, cognitive, behavioral and personal characteristics may have an influence on plausibility. It is valuable to discover the possible determinants of plausibility that lead us to find ways to increase plausibility. Considering the significance of this study, the purpose and the research questions are presented in the following sections.

1.3 The purpose of the study

The primary purpose of the current study was to investigate the role of PSTs' cognitive, behavioral and personal characteristics on their plausibility perceptions of GCC. Also this study aimed to examine PSTs' understanding and plausibility perceptions of GCC. Another purpose of this study was to explore if there is a relationship between PSTs' understanding and plausibility perceptions of GCC.

1.4 Research questions

Considering the purpose of the current study, there were four main research questions that this study tried to answer. Visual representation of the research questions is presented in Figure 2. The research questions were as follows:

Research Question 1: What are PSTs' plausibility perceptions of GCC?

Research Question 2: What is PSTs' understanding of GCC?

Research Question 3: Is there a relationship between PSTs' plausibility perceptions and understanding of GCC?

Research Question 4: Do understanding of GCC, degree of willingness to act, need for cognition, and need for closure predict PSTs' plausibility perceptions of GCC?

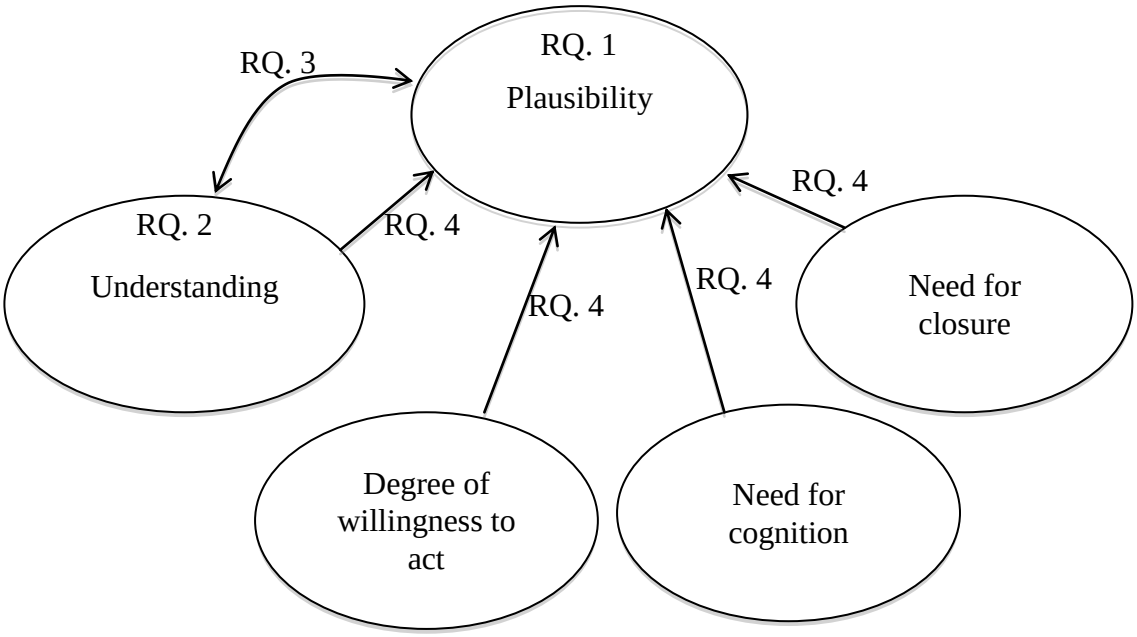


Figure 2 Visual representation of the research questions

The next chapter is aimed at presenting the review of the literature to reveal the theoretical background of the study and the findings of the related research. First of all, GCC and its significance are introduced. Second, conceptual change models and the role of plausibility on conceptual change are presented. Third, literature on plausibility and GCC is given. Finally, literature on the role of cognitive, behavioral and personal variables in plausibility perceptions of GCC is presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Global climate change and its significance

"Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2014, p. 6). As this study is interested in the change in the Earth's climate, not the climate of a particular area on the planet, the term global climate change (GCC) is used.

Earth's climate has always been changing and there may be many reasons for this change such as: the amount of energy releasing from the Sun or the eruption of a volcano on Earth. However, human activities that have added greenhouse gases (carbon dioxide, methane, nitrous oxides, ozone and water vapor) to the Earth's atmosphere over the past century are considered as the main cause for the current change in the global climate. This is also defined as human-caused climate change, "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods." (United Nations Framework Convention on Climate Change, Article 1, Definitions, p. 2).

Mainly, the layer of greenhouse gases in the atmosphere that acts as a thermal blanket of Earth (known as greenhouse effect) has been increased with human activities, which causes the global temperatures to rise (i.e. global warming) and global climate to

change as well. These changes may cause a shift in precipitation patterns, changes in agriculture, extreme weather events and alteration in environmental systems like the extinction of species. Additionally, human health, wealth and safety may be sensitive to climate change (Stern, 2007).

When considering the science-related, policy-relevant and socially controversial nature of GCC, it is regarded as a socio-scientific issue (SSI). SSI is defined as "the consideration of ethical issues and construction of moral judgments about scientific topics via social interaction and discourse" (Zeidler et al. 2005, p. 360). SSI education is substantial in terms of raising scientifically literate citizens (Zeidler et al., 2005). In the last decade, SSI has started to be included in many countries' science curriculums. Also, the Ministry of National Education in Turkey (MONE) included SSI in the science curriculum in 2013. SSI in the Turkish curriculum was defined as the use of scientific and analytical thinking skills and decision-making strategies regarding socio-scientific problems (MONE, 2013). Considering the multidisciplinary nature of SSI, in order to promote a knowledgeable citizenry, it is fundamental to design curriculum instructions in different fields of education.

Although students bring preconceptions while learning any subject, further difficulties are faced in learning GCC, because GCC education covers complex scientific knowledge, multidisciplinary explanations, uncertainty about future predictions, and open-ended disputes about connections to everyday life. Some of the disputes about GCC are on whether it is naturally oriented or human-caused, the amount of influence of human activities, and the magnitude of global and regional consequences. Research has shown that learners have various ideas about GCC, most of which consist of naïve concepts or misconceptions that oppose current scientific views

(Rye et al., 1997; Kilinc et al., 2008; Lombardi et al., 2013). Some of the major misconceptions are associating the ozone layer depletion with GCC and confusing climate with weather and seasons (Boyes & Stanisstreet, 1997; Ozdem, Dal, Ozturk, Sonmez, & Alper, 2014; Pruneau et al., 2003). For instance, the major erroneous idea of students is that the thinning of the ozone layer results in more sunlight reaching the Earth, which causes an increase in global temperature (e.g. Boyes & Stanisstreet, 1997). Some of the naïve concepts are, for example, having difficulty in believing in the human impact on climate and being doubtful about the scientific idea of GCC as it is mostly explained by modeling (Kilinc et al., 2008).

As well as determining the conceptions of the learners, it is also significant to discover teachers' conceptions about GCC as teachers' scientific knowledge has an influence on student understanding (Brickhouse, 1990). Further, Oversby (2015) stated "it is cross-disciplinary and therefore can be a subject challenge for many teachers" (p. 23). Findings of research with pre-service teachers (PSTs) revealed similar misconceptions among students about the global climate such as associating ozone layer depletion with GCC (e.g. Feierabend et al., 2010; Kalipci et al., 2009), confusing short-term weather events and climate, and relating pollution events directly to GCC (litter and waste disposal) (e.g. Papadimitriou 2004).

One of the most significant models to overcome misconceptions in science is the conceptual change model. The next section focuses on the conceptual change model and one of the most important constructs in the model, which is plausibility.

2.2 Conceptual change model and plausibility

Conceptual change is originally defined as the reconstruction of knowledge and the integration of new and existing ideas (Posner et al., 1982). Conceptual change has been studied in many fields such as cognitive psychology, social psychology and science education (Dole & Sinatra, 1998). Each field brings a different perspective to the change process. According to Anderson and Pearson (1984), the focus of cognitive psychology is conceptual knowledge and the representation of concepts in memory. Social psychologists are mainly interested in beliefs and attitudes and adapt the methodology and theory of cognitive psychology in order to disclose the representation of beliefs and attitudes in memory (Chaiken & Stangor, 1987). Alternatively, science education researchers often focus on explaining knowledge acquisition and knowledge reconstruction in the light of the history and philosophy of science (Posner et al., 1982).

In science education, the initial conceptual change model emerged from the work of Posner and his colleagues (1982) that was rooted in how students give meaning to the world. Children start constructing knowledge about the world by their daily life experiences before they start formal education (Duit & Treagust, 2003; Posner et al., 1982; Vosniadou & Ioannides, 1998). However, this constructed knowledge may not always be in line with the formal information that is given at school. In science education research, the existing non-compatible conceptions of the learners are defined as preconceptions, alternative frameworks, and misconceptions (Posner et al., 1982), which need to be addressed in formal education.

According to Posner and his colleagues (1982), conceptual change is necessary to make the learning meaningful, the basis of which lies in the notions of Piaget that are disequilibrium, assimilation and accommodation. Assimilation is defined as the use of

existing knowledge to give meaning to the new phenomena, whereas accommodation requires the replacement and reorganization of the initial concepts. Four common conditions were determined for the accommodation of knowledge. These conditions are: (1) dissatisfaction of the learner with existing knowledge, (2) intelligibility, (3) plausibility, and (4) fruitfulness of the new conception (Posner et al., 1982). With the conceptual change model, teachers are expected to construct dissatisfaction with the prior concept and this causes a trigger to replace it with an intelligible, plausible and/or fruitful status among learners. An intelligible conception makes sense if the new concept is understood or comprehended by the learner; a plausible conception has to be believable and worthy of being accommodated with the understandable meaning of the conception; and the conception is fruitful when the learner is able to solve related problems and search for new ways to solve a problem.

By considering the accommodation of a new conception in the conceptual change process, Treagust and Duit (2008) investigated the theory–practice gap of conceptual change in science education in terms of status constructs - intelligibility, plausibility and fruitfulness. Students' conceptual status, epistemological and conceptual profiles were examined in epistemological conceptual changes, fundamental categories and properties of the world were explored in ontological conceptual changes, students' interests and motivation were investigated in affective conceptual changes, and the mindfulness of students was studied in intentional conceptual changes. The findings of the study included challenges at theoretical, methodological and practical points by providing guidance (1) for the development of instructional design for science education, (2) for the need for more than one source of evidence to judge conceptual change, and (3) for the importance of the science teachers' views about instruction and conceptual change.

In another study about the conceptual change model, Beeth (1998) investigated the effects of using status constructs of intelligibility and plausibility on conceptual change learning when stating ideas about a scientific topic. Specifically, Beeth (1998) aimed at examining the understanding of the students and the teacher of the definitions of status terms (e.g., intelligibility and plausibility), and how they reflected their understanding of status terms while learning new science concepts. Findings of the study implied that using status constructs of intelligibility and plausibility helped students to have a better understanding of their own ideas and the ideas of others with attending to metacognitive discussions in the conceptual learning process. Furthermore, using this approach as a form of conceptual change instruction provided an opportunity to spend more time on students' ideas and their reasons for those ideas.

Research findings on status constructs revealed that learners might focus on scientific ideas and make evaluations among ideas through intelligible, plausible and/or fruitful status (Beeth, 1998; Treagust & Duit, 2008). For the purpose of the present study, the focus will be on the role of plausible status on conceptual change. Recently, Lombardi, Sinatra and Nussbaum (2013) have defined plausibility as "a judgment of relative potential truthfulness when evaluating competing explanations" between the new information and existing mental representations (p. 3). Research also suggests that scientifically accurate concepts should be plausible in order for learners to reconstruct knowledge throughout the learning process (Duschl & Gitomer, 1991; Treagust & Duit, 2009), to evaluate an incoming concept (Treagust & Duit, 2008) and to create a strong conceptual change (e.g. Dole & Sinatra, 1998; Duit & Treagust, 2003). In particular, the plausibility of new conception requires making cognitive judgments (Connell & Keane, 2004; Lombardi et al., 2016) and a deeper mental processing that "facilitates encoding

and learning" (Pintrich et al., 1993, p. 174). Accordingly, plausibility perceptions give an account of association to previous knowledge, the complexity of associations and require critical evaluation (Connell & Keane, 2004; 2006; Dole & Sinatra, 1998).

Dole and Sinatra (1998) pointed out the importance of plausibility and viewed conceptual change as the "reconceptualization of change process" that takes science education, cognitive and social psychology research into consideration (p. 110). The change process was defined in the "Cognitive Reconstruction of Knowledge Model (CRKM)" (p. 118). In the CRKM, Dole and Sinatra (1998) focused on the interaction between the quality of the learners' existing knowledge, their motivation to process new information, and the properties of the message that promote a change in the existing conception. The quality of existing knowledge was classified according to its "strength, coherence and commitment", where "strength" indicates the "richness of a learner's existing idea"; "coherence" indicates the "conceptual coherence of the individual's existing knowledge" and "commitment" indicates "learner's need to believe" (Dole & Sinatra, 1998, p. 118).

The second focus of the CRKM is the motivation of learners to process new information. The CRKM reveals four characteristics of motivation to change. In addition to the "dissatisfaction" of the learner as a motivating facet (Posner et al, 1982), the CRKM indicates "personal relevance, social context and need for cognition" of the learner for the process of change (Dole & Sinatra, 1998, p. 119). Moreover, the new message needs to be "comprehensible, plausible, coherent and rhetorically compelling" in order to cause a change in the existing knowledge (Dole & Sinatra, 1998, p. 120).

According to the CRKM model, a message can be considered as comprehensible if it is conceptually easy to comprehend for a learner to relate the message with existing

knowledge. A coherent message needs to associate the related information in a conceptual integrity, and a rhetorically compelling message needs to be convincing in the use of language with rational justifications for the learner. Finally, the CRKM describes the plausible message as reasonably true in terms of the quality of evidence that leads the learner to find the information truthful.

Recently Lombardi, Nussbaum and Sinatra (2016) presented a model that aimed at explaining "the role of plausibility judgments in conceptual change (PJCC) with implications for epistemic cognition" (p. 1). The PJCC Model can be considered as the enhanced version of the CRKM by trying to clarify "how plausibility judgments may form and be reappraised through explicit cognitive processing" (p. 15). In the PJCC model, researchers incorporated the factors associated with plausibility judgment and the judgment's disposition. The PJCC posits the importance of "source validity pre-processing" and the possible determinants, which are "corroborative and coherent alignment, information complexity, perceived conjecture, source credibility perceptions, and heuristic rules and biases" (p. 11). Lombardi and his colleagues (2016) argued that these determinants may play a role in the judgment's plausibility. For instance, the complexity of an issue may have a negative influence on source validity, which may bring implausibility to a judgment.

The main focus of the PJCC is on the type of processing about the judgment, whether it is explicit, implicit or both. The degree of evaluation, which is determined by the type of processing, relies on epistemic dispositions and motives, motivation and topic emotions (p. 11). Dole and Sinatra (1998) also pointed out the influence of motivation and personal characters like epistemic dispositions and motives in the

plausibility of a judgment. The PJCC Model tries to explain the impact of these traits on the plausibility of the judgment as being either explicit or implicit.

Much research has presented the findings of using status constructs in conceptual learning (e.g. Treagust & Duit, 2008; Beeth, 1998). Among the status constructs, plausibility is considered as one of the most crucial conditions in creating strong conceptual change (e.g. Dole & Sinatra, 1998; Lombardi et al., 2016). Posner and his colleagues' (1982) conditions for conceptual change; Dole and Sinatra's (1998) CRKM; and Lombardi and his colleagues' (2016) PJCC Model revealed plausibility in conceptual change from different perspectives. By keeping the conceptual change models in mind, the next section focuses on the literature concerning plausibility and GCC.

2.3 Plausibility and global climate change

Plausibility is an important construct in the conceptual change process (e.g. Dole & Sinatra, 1998; Pintrich et al., 1993). Even though there are different theoretical perspectives with regard to conceptual change, plausibility has been addressed in each model. This is because conceptions must be plausible for conceptual understanding of complex scientific issues like GCC, which "has substantial plausibility gaps" (Lombardi et al., 2016, p. 18). The following paragraphs explain the role of plausibility in GCC education by considering different conceptual change models.

Posner and his colleagues (1982) determined the status constructs that lead to conceptual change. In this model, plausibility is a fundamental status construct, which needs to be "a result of consistency of the concepts with other knowledge" (Posner et al.,

1982, p. 214). Zeidler and his colleagues also stated that learning controversial issues like GCC requires scientific reasoning, analytical evaluation and "decision making in terms of logical constructs such as internal consistency and coherence" (p. 368). Therefore, plausibility should be considered in GCC education while analyzing the consistency of scientific explanations with social, political and economic decisions (Stern, 2007).

In the CRKM, Dole and Sinatra (1998) stated that one of the features of the new message is being plausible to cause a change in the existing knowledge. For instance, human influence on current climate may be considered as a new message. Learners may understand the scientific data about the addition of greenhouse gases to the atmosphere through human activities (the message is intelligible). However, individual or global human influence on Earth's climate may not be reasonably true in a way that leads the learner to find the information truthful (the message is implausible). Finding the new message implausible may have an impact on the learners' motivation to process new information and may prevent the change in the existing conception.

According to the PJCC Model, Lombardi and his colleagues (2016) claimed that the complexity of an issue may lead to the implausibility of a judgment. The complex scientific background and controversial social structure of GCC influence the judgments' plausibility. Moreover, the PJCC Model tries to explain the impact of epistemic dispositions, motivations and emotions on the plausibility of the judgment. As a SSI, learners have various dispositions, motivations and emotions while learning about GCC. Therefore, the next section reviews the literature about the role of cognitive, behavioral and personal variables in plausibility perceptions of GCC.

2.4 The role of cognitive, behavioral and personal variables in plausibility perceptions of GCC

2.4.1 Cognitive variable: Understanding of GCC

Research into the understanding of GCC has revealed the conceptions and the misconceptions of learners. This section firstly focuses on the IPCC that reviews and reveals climate change related information for worldwide understanding of climate change. Secondly, studies about learners' understanding of GCC at various ages are reviewed. Then, the literature about PSTs' understanding of GCC and their misconceptions is reviewed. Finally, the literature about the plausibility and understanding of GCC is revealed.

The Intergovernmental Panel on Climate Change (IPCC) is an international organization established to provide an objective source of information about climate change. The IPCC currently has 195 member countries and includes thousands of scientists. The IPCC does not conduct research; rather it aims at assessing the science related to climate change. Currently, the IPCC is divided into three working groups; Working Group I deal with the physical science of climate change, Working Group II deals with climate change impacts and adaptation, and Working Group III deals with the alternative mitigation strategies for climate change (IPCC, 2013; 2014). In addition to scientists, governments also participate in the review process where decisions are taken, reports are accepted and governments verbally recognize the authority of the IPCC reports. Consequently, the IPCC reports are considered as "policy-relevant and yet policy-neutral, never policy-prescriptive" (Beck, 2015, p. 1).

Several research projects have been conducted to investigate learners' understanding of GCC (e.g. Arslan et al., 2012; Leiserowitz & Smith, 2010; Pruneau et al., 2003). For instance, Leiserowitz and Smith (2010) conducted a study with 2030 adults in the United States in order to reveal their understanding of the mechanism of the climate system, its causes and consequences. The results were analyzed by classifying the participants into six groups by considering their beliefs, concerns and motivations (the groups are named as alarmed, concerned, cautious, disengaged, doubtful, and dismissive (p. 2)). The study showed that alarmed and concerned participants mostly have a higher understanding of GCC. Although there are differences in the number of gaps, all six groups had knowledge gaps about the structure of climate systems. Moreover, there are common misconceptions among participants like the attribution of ozone layer depletion to GCC and the contribution of other environmental problems to GCC. As GCC has long-term and combined effects with other environmental issues, it is hard for learners to differentiate the consequences from others and point out specific events related to GCC (Daniel et al., 2004).

In another study, Pruneau and his colleagues (2003) also investigated the participants' ideas, beliefs and knowledge about the signs, causes and consequences of GCC. The research project was conducted with 190 participants including adults, teenagers and children. The results revealed that participants were not very familiar with GCC and similarly climate change was associated with other environmental issues such as ozone layer depletion. Moreover, participants either believed in the incapability of the general human population to influence the climate, or perceived its happening in the far future that would not affect them. Likewise, the findings of different studies on the risks and impacts of GCC showed divergent ideas of adults, such as: "no consequences in my

own life, spread of disease, extreme weather events, difference in waterways, unusual presence or absence of species" (Pruneau et al., 2001, p.128), "temperature rise, restriction of four seasons to two, sudden changes of weather" (Papadimitriou, 2004, p. 301), "change in precipitation patterns, melting glaciers, human health effects (e.g., skin cancer, sunburn, psychological changes)" (Bostrom et al., 1994, p. 968).

As well as studies conducted with participants of various ages, research on PSTs' understanding of GCC reports some misconceptions and knowledge gaps. In a study, Arslan and her colleagues (2012) investigated the misconceptions of PSTs on "atmosphere related environmental problems" (p. 1667). The study was conducted with 256 PSTs in an urban southwestern university in US. The participants were studying in different fields such as early childhood education, middle school and high school education. The findings of the study showed that the majority of the participants had a limited understanding of "atmosphere related environmental problems" (p. 1667) and have some misconceptions, such as "GW (i.e. global warming) is caused by OLD (i.e. ozone layer depletion)", "The GE (i.e. greenhouse effect) is a totally harmful phenomenon for mankind", "Using public transportation reduces OLD (i.e. ozone layer depletion)" (Arslan et al., 2012, p. 1680).

Another study examined PSTs' perceptions of the future impacts of GCC (Bozdogan & Yanar, 2010). Sixty-eight PSTs in the department of primary education at a public university in Turkey participated in the study. The results revealed that all of the participants had the necessary knowledge, but almost half of the participants had misconceptions about GCC. Also, the study conducted with 24 PSTs in a public university in Turkey revealed that most of the participants had misconceptions about the greenhouse effect and climate change (Oluk & Oluk, 2007). In addition, Kahraman and

his colleagues (2008) investigated awareness and knowledge levels of PSTs who were studying in a public university in Turkey. The results of the study showed that the participants had low levels of awareness and knowledge of GCC and they also had some misconceptions.

In the last decade, there are a few studies disclosing the relationship between plausibility and the understanding of GCC among middle school students (Lombardi et al., 2013), college students (Lombardi & Sinatra, 2012; Lombardi et al., 2014), and PSTs and in-service science teachers (Lombardi & Sinatra, 2013). These studies showed a significant relationship between plausibility and the understanding of GCC, except the study conducted with PSTs and in-service science teachers (Lombardi & Sinatra, 2013).

Lombardi and Sinatra (2012) reported that theirs was the first empirical study showing the relationship between plausibility and conceptual change. The study explored college students' plausibility perceptions of human-induced climate change (HICC). The participants were eighty-three undergraduate students who were enrolled in a global warming course and a physical geography course at a university in the United States. The instruments about weather and climate distinctions, knowledge and plausibility perceptions of HICC were implemented at the beginning and at the end of the semester as pre- and post-tests. Findings of the study revealed that there is "a significant relationship between plausibility perceptions and changes in knowledge over time" (Lombardi & Sinatra, 2012, p. 211). Moreover, their study revealed, "as plausibility perceptions about human-induced climate change increase, so do changes in understanding about weather and climate distinctions" (p. 212).

Lombardi, Seyranian and Sinatra (2014) investigated the relationships between "source effects", particularly "trustworthiness and expertise", and plausibility

perceptions of university students from the Psychology Department at a university in the US. Results of the study revealed that "perceptions of certainty about claims made in a text about climate change and source credibility (trustworthiness) predicted plausibility perceptions of scientific statements about climate change" (p. 87). They reported that there is a significant relationship between plausibility perceptions and knowledge about HICC. These findings supported Lombardi et al.'s (2016) PJCC Model.

However, in another study, Lombardi and Sinatra (2013) examined pre-service and in-service teachers' emotions about teaching GCC and their knowledge of weather and climate distinctions. The participants were forty-five pre-service teachers, sixteen in-service teachers who had taught GCC before, and twenty-four in-service teachers who had not taught GCC. According to the results, emotions about GCC and emotions about teaching GCC predict plausibility perceptions of GCC, whereas knowledge of weather and climate distinctions did not predict plausibility perceptions of GCC.

Recently Lombardi, Danielson and Young (2016) explored university students' "critical evaluations and plausibility perceptions of climate change when reading two different types of text: expository and refutation" (p. 74). Participants were ninety-five undergraduate students drawn from an educational psychology pool at a university in US. Their findings showed that there was a significant increase in plausibility and knowledge after reading the refutation text, but there was no significant change in either variable after reading the expository text. The results of the study were important in revealing the influence of evaluation on plausibility and knowledge.

In the light of the literature, the present study is aimed at expanding our knowledge about the relationship between PSTs' plausibility perceptions and

understanding of GCC. The current study was conducted in the need for additional research that investigates PSTs' plausibility and understanding of GCC.

2.4.2 Behavioral variable: Degree of willingness to act

It is clear that we have started to observe the consequences of GCC (IPCC, 2014). However, the future changes, risks and the impacts of climate are hard to predict due to the influence of various factors on greenhouse gas emissions such as technological development, land use, economic and population growth. To reflect the current understanding and the uncertainty about the climate system, the IPCC (2014) presented a set of emission scenarios of greenhouse gases with the projected assumptions of global temperature change. Four main scenario families were determined to represent economic versus environmental and global versus regional foci.

The practical challenge about these scenarios is to reduce greenhouse gas emissions with individual, collective, governmental and global actions (Boyes, Skamp, & Stanisstreet, 2009; IPCC, 2014). Particularly the challenge is about willingness to undertake specific actions for responsible environmental behavior as a citizen (McBeth & Volk, 2009). However, some problems need to be considered when expecting a change in learners' stances and behaviors, such as "conceptual difficulties", "specific misconceptions" and "commitment to a particular point of view" (Sinatra, Kardash, Taasoobshirazi, & Lombardi, 2012, p. 1-2).

A considerable amount of research has been conducted to investigate the willingness of people to take climate friendly actions (e.g. Boyes et al., 2009; Fortner et al., 2000; Kilinc, Boyes, & Stanisstreet, 2011; Malandrakis, Boyes, & Stanisstreet, 2011;

Rodriguez et al., 2011; Sinatra et al., 2012). Most of these studies have revealed at least a reasonable amount of willingness to take actions such as learning more about environmental issues and decreasing the use of electricity (e.g. Boyes et al., 2009; Fortner et al., 2000; Kilinc et al., 2011). However, common findings of research suggest that most people show only a small amount of willingness to take action on using public transport and using small cars (e.g. Boyes et al., 2009; Fortner et al., 2000; Kilinc et al., 2011).

One of the studies that inspired the current study was conducted by Boyes and his colleagues (2009). The study aimed at investigating the beliefs of secondary school students (n = 500) about particular environmental actions and their intention to act. The researchers developed a questionnaire to measure the intensity of the relationships between "degree of willingness to act" and "believed usefulness of action" that provides information for "potential effectiveness of education" (Boyes et al., 2009, p. 661). In other words, the researchers suggest that if the relationships between the degree of willingness to act and believed usefulness of action are strong, environmental education will be more effective. The findings revealed more willingness of participants for some actions such as switching off unused electrical devices, while less willingness for actions such as using public transport, buying small cars and buying new items less frequently.

Kilinc and his colleagues (2011) used the same instrument to examine Turkish school students' beliefs about specific actions and their intention to undertake those actions. Participants were 897 students from grade 6 to 10. Results of the study showed that the majority of participants were willing to take action on paying for the planting of trees and on electricity use and insulation at home. On the other hand, they were

unwilling to pay extra money for low-carbon energy sources like nuclear generators or renewable sources or to use public transportation more or to reduce meat consumption.

2.4.3 Personal variables: Need for cognition and need for closure

The personality of individuals may relate to their disposition toward knowledge (Cacioppo, Petty, Feinstein, & Jarvis, 1996). The need for cognition is a personality variable that aims at explaining the desire of individuals to "engage in and enjoy thinking" on complex cognitive issues (Cacioppo & Petty 1982, p. 116). In other words, Cacioppo and his colleagues (1996) explained need for cognition as "just as cold is the relative absence of heat and darkness is the relative absence of brightness, low need for cognition is the relative absence of the motivation for effortful cognitive activities" (p. 198). Lower need for cognition is associated with disengagement in idea evaluation and critical thinking. Therefore, individuals with a lower need for cognition may refuse to learn about GCC or they may refute**,** i.e. reject, the whole concept of GCC. Conversely, Lombardi and Sinatra (2013) reported that individuals with a higher need for cognition enjoy effortful thinking and may have a desire to learn about GCC.

Moreover, disposition toward knowledge is closely related to epistemic motivation (Cacioppo et al., 1996). Webster and Kruglanski (1994) defined epistemic motivation as a desire to have accurate answer(s) and solution(s) to ambiguous situations. The need for closure is an epistemic motivation where having a high need for closure is considered as being uncomfortable with ambiguity and looking for concrete answers, whereas a lower need for closure is related to open-mindedness and seeking out possible answers (Webster & Kruglanski, 1994). In particular, five main subsets were

determined to depict the need for closure of an individual, which are “structure”, “ambiguity”, “decisiveness”, “predictability” and “closed-mindedness” (Webster & Kruglanski, 1994, p. 1049-1050).

Individuals with a high need for closure expect to have clearly defined order and structure in their personal lives and experience unambiguous situations with an expectation of permanent knowledge that is not challenged by possible explanations. Consequently it is crucial to consider the need for closure of individuals when exploring their plausibility perceptions of a complex issue. Yet the need for closure of PSTs may have an influence on acquiring an understanding of certain issues (Sinatra, Southerland, McConaughy, & Demastes, 2003) and may have an impact on their preference for teaching those issues.

Research conducted by Sinatra and her colleagues (2012) examined the relationship among participants’ need for cognition, need for closure and their intention to take action to mitigate the effects of GCC. One hundred forty undergraduate students who enrolled in an educational psychology course participated in the study. They were asked to read a text about GCC and were pre-and post-tested on these variables. The results revealed the significant negative relationship between closed-mindedness (a subset of need for closure) and willingness to take action, whereas there was a significant positive relationship between the need for cognition and willingness to take action to reduce the impacts of GCC. There was also a significant negative correlation between closed-mindedness and the need for cognition.

Recently, Lombardi and Sinatra (2013)’s study on pre- and in-service teachers’ emotions concerning teaching about human-caused climate change also examined the disposition of participants toward knowledge. Their findings suggest that there is a

negative relationship between decisiveness (a subset of need for closure) and participants' plausibility perceptions of GCC. Theoretically, this result may specify that individuals who have a high tendency to make immediate decisions may also have a disposition to make heuristic evaluations (Dole & Sinatra, 1998; Lombardi & Sinatra, 2013). However, the decisiveness of PSTs and in-service teachers who do not teach about GCC is higher than the decisiveness of in-service teachers who currently teach about GCC. Additionally, their results showed that there is no relationship between need for cognition and plausibility perceptions.

CHAPTER 3

METHODOLOGY

This chapter gives detailed information about the methodology of the research. Sample, study context, research design, data collection procedure, definition of key terms and variables, instruments and the data analyses of the study are described.

3.1 Sample

The first phase of data collection was the pilot study that was conducted to test the psychometric properties of the instruments. In the second phase, the data obtained from the main sample was used to investigate the research questions. Both the pilot and the main study were conducted in the Faculty of Education of a public university in Turkey. In the next sections, the sample for the pilot and the main study is described, and the detailed information about the study context is explained.

3.1.1 Sample for the pilot study

A total of 111 undergraduate and graduate students at a public university in Turkey participated in the pilot study. Two of the participants' responses were extracted because a large amount of their data was missing (N = 109). Participants were predominantly female 91%. The study was conducted with undergraduate and graduate students from

the Primary Education, and Secondary School Science and Mathematics Education Department in 2014-fall semester (see Table 1).

Table 1. Study Fields and the Grade Distributions of the Pilot Sample

Study field	Grade	N	%
Preschool Education	1	32	29.5
	2	42	38.5
	3	3	2.8
Primary Mathematics Education	3	3	2.8
Secondary Mathematics Education	4	4	3.6
Secondary Physics Education	4	4	3.6
	5	3	2.8
Graduate Program in Secondary School Science and Mathematics Education	Graduate	4	3.6
Graduate Program in Primary Education	Graduate	14	12.8
Total		109	100

3.1.2 Sample for the main study

Participants of the main study were determined by convenient sampling. The study was conducted with senior pre-service teachers (PSTs) studying at a public university in Turkey in 2015- spring semester. The programs of PSTs involved in the study were Preschool Education (n = 39), Foreign Language Education (n = 41), Primary Science Education (n = 31), Primary Mathematics Education (n = 27), Secondary Mathematics Education (n = 22), Secondary Physics Education (n = 24) and Secondary Chemistry Education (n = 19). The target population of the study was 283 and the data was

collected from an accessible population of 203 participants. Before the data analysis, missing data and outliers were determined. Three outliers and one extreme outlier were detected, and in total the data of 4 participants was removed from the study (see APPENDIX A, Figure 10 and Figure 11). In particular, the sample of the main study was 199, where %70 of the target population participated in the study.

The programs in Preschool Education and Foreign Language Education, which offer a Bachelor of Arts degree, do not include natural-science courses like physics, chemistry, biology or courses including environmental problems in their program. However, Primary Science Education, Primary Mathematics Education, Secondary Mathematics Education, Secondary Physics Education and Secondary Chemistry Education Programs offer a Bachelor of Science degree and include science courses. (see Table 2).

Table 2. Field of Study Distributions of Participants

Study Field	N	%
Primary Science Education	30	15
Primary Mathematics Education	26	13
Secondary Mathematics Education	21	11
Secondary Physics Education	24	12
Secondary Chemistry Education	19	10
Preschool Education	39	20
Foreign Language Education	40	20
Total	199	100

3.2 Study context

The university where the study was conducted is a public university in Turkey. The Faculty of Education at this university is considered as highly selective in terms of accepting the highest scored students of the national exam. Further, this university has two properties concerning climate change.

Firstly, this university has a center for climate change and policy studies that gathers climate data for different regions and conducts research on climate related subjects. Besides conducting research, the center also organizes conferences and panels on issues related to climate and releases a weekly newsletter to provide information about regional, national and global news about climate change.

Secondly, the university offers elective courses specifically about Earth's climate and climate change such as: Global Climate Change, Climate Change Impacts, Mitigation and Adaptation courses in the Department of Environmental Sciences, Climate Change and Energy Efficiency, Climate courses in the Physics Department.

3.3 Research design

Survey research design was conducted to answer the research questions of the study. In survey research, the researcher attempts to gather information about people's opinion on a subject field in order to test hypotheses (Gay, Mills, & Airasian, 2011). In the current study, survey data was collected by asking questions via questionnaire. In general, the results of the data included similarities, differences and variances of the responses. Descriptive, correlational and prediction analyses were conducted to answer the research questions.

3.4 Procedure of the study

After the review of the literature, the topic was selected and the research questions were determined. By reviewing the literature, the demographic information form was composed and the instruments were chosen to answer the research questions. Expert judgments were obtained to confirm the face and content validity of the instruments. The required permission for conducting research was obtained from the Ethical Committee of the university at which the data was collected (see Appendix B). The pilot study was conducted with 109 participants to test the psychometric properties of the instruments in 2014-fall semester.

Following the data collection from the pilot sample, the psychometric properties of the instruments were tested. The reliability analyses indicated satisfactory results. At the end of the evaluation of the psychometric qualities of the instruments, the participants of the main study were asked to sign the consent form before participating in the study (See Appendix C). With the permission of each participant, the data was collected from the main sample in 2015-spring semester by using the determined instruments. Implementation of the instruments took about 30-45 minutes and the researcher was present in the classroom during data collection to give a brief explanation about the study and to clarify the confidentiality of information.

3.5 Definitions of key terms and variables

3.5.1 Conceptual definitions

- Climate Change*: "*Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2014, WG II, p. 6).
- Human-caused climate change: "A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere" (United Nations Framework Convention on Climate Change, Article 1, Definitions, p. 2)
- Plausibility perceptions: "A judgment of relative potential truthfulness when evaluating competing explanations" between the new information and the existing mental representations (Lombardi et al, 2013, p. 3).
- Willingness to take action*:* The willingness to undertake specific actions for responsible environmental behavior (McBeth & Volk, 2009).
- Need for cognition: "The tendency for an individual to engage in and enjoy thinking" (Cacioppo & Petty 1982, p. 116).
- Need for closure: "The desire for predictability, preference for order and structure, discomfort with ambiguity, decisiveness, and close-mindedness" (Webster & Kruglanski, 1994, p. 1049-1050).

3.5.2 Operational definitions

- Plausibility perceptions: The summated score of responses to the Plausibility Perceptions Measure, based on a ten-point summated rating scale identifying degree of plausibility and given a numerical value ranging from 1 = greatly implausible or even impossible to 10 = highly plausible.
- Understanding of GCC: The summated score of responses to the Understanding of Climate Change Instrument, based on a five-point Likert scale, from 1 = strongly disagree to 5 = strongly agree.
- Willingness to take action: The summated score of responses to the Degree of Willingness to Act Scale, based on a five-point Likert scale, from 1 = probably not to 5 = definitely.
- Need for cognition: The summated score of responses to the Need for Cognition Scale, based on a five-point Likert scale, from 1 = extremely uncharacteristic of me to 5 = extremely characteristic of me.
- Need for closure: The summated score of responses to the Need for Closure Scale, based on a six-point Likert scale, from 1 = strongly disagree to 6 = strongly agree.

3.6 Instruments

3.6.1 Demographic form

The demographic form was used to collect information about the participants (See Appendix D). Questions pertaining to the participants' gender, the place where they

grew up, their major field of study, information about taking a course on environmental education and belonging to an environmental group or organization. Of the participants, 83% were female (n = 165) and 17% were male (n = 34) (see Table 3).

Table 3. Gender Distribution of Participants

Department	Female (%)	Male (%)
Primary Science Education	90	10
Primary Mathematics Education	73	27
Secondary Mathematics Education	67	33
Secondary Physics Education	67	33
Secondary Chemistry Education	74	26
Preschool Education	95	5
Foreign Language Education	95	5
Total	83	17

The demographic data also included participants' statements about their hometown (place where they grew up), taking a course about environmental education, and belonging to an environmental group or organization (see Table 4). According to Table 4, most of the participants stated that their hometown was a big city (58%), whereas 30% said they grew up in a small town and 12% said they grew up in a rural area. About taking a course on environmental education, nearly half of the participants answered 'yes' (42%). However, the majority of the participants (88%) stated that they did not belong to, or have never belonged to an environmental group or organization.

Table 4. Demographic Data of Participants

Participants	Answers	(%)
Hometown (the place you grew up)	Rural area	12
	Small town	30
	Big city	58
Taking a course about environmental education	Yes	42
	No	58
Belonging to an environmental group or organization	Yes	12
	No	88

3.6.2 Descriptive information and descriptive statistics of each instrument

Five different instruments were used in the study in order to find answers for the research questions. The mean, standard deviation, minimum and maximum scores of participants in the pilot study on each instrument were shown in Table 5. Considering the descriptive information of the instruments, the next sections of the study aimed at describing each instrument in more detail.

Table 5. Descriptive Statistics of Pilot Study Sample on Each Instrument

Instrument	N	Min.	Max.	Mean	Std. Dev.	Cronbach's Alpha
Plausibility Perceptions Measure	109	9.00	70.00	52.20	11.82	.91
Understanding of GCC	109	85.00	125.00	101.48	8.57	.83
Degree of Willingness to Act Scale	80	53.00	100.00	73.23	9.89	.79
Need for Cognition	109	55.00	86.82	66.87	6.63	.74
Need for Closure	109	38.00	83.00	59.60	8.81	.76

The possible score range is 8-80 for plausibility perceptions measure, 25-125 for understanding of GCC instrument, 20-100 for degree of willingness to act scale, 18–90 for need for cognition, 6-90 for need for closure

3.6.3 Plausibility perceptions measure (PPM)

Lombardi and Sinatra (2012) designed the PPM instrument by using the statements from the Fourth Assessment Report of IPCC (2007) in order to examine participants' plausibility perceptions of GCC (See Appendix E). The first two items are about evidence for GCC, the next three items focus on evidence supporting a human link to GCC and the last three items are predictions about future impacts of GCC. The focus of each item in the instrument was presented in Table 6.

Table 6. Focus of Each Item in PPM

Focus	Item numbers
Evidence for GCC	1 – 2
Evidence for supporting human link to GCC	3 – 4 – 5
Predictions about future impacts of GCC	6 – 7 – 8

The instrument was created according to the Fourth Assessment Report of the IPCC (2007). However, the present study was conducted after the release of the Fifth Assessment Report of the IPCC (2014). Before conducting the study, a climate expert checked the items in the instrument as to whether or not they covered the current scientific findings about GCC according to the Fifth Assessment Report of the IPCC (2014). Expert analysis revealed the content validity of the instrument.

The instrument has eight statements and the participants rated each statement on a ten-point Likert scale (1 = greatly implausible or even impossible and 10 = highly plausible). Possible minimum score was 8 and the possible maximum score was 80 for the instrument. Higher scores indicated higher plausibility perceptions of GCC. The Cronbach's alpha reliability value of the instrument was obtained as 0.8 (Lombardi & Sinatra, 2012), which indicates a good internal consistency for the scale. The Cronbach's alpha value of PPM was .91 for the pilot sample of the current study (n = 109).

3.6.4 Understanding of GCC instrument

An instrument for understanding global climate change (GCC) was used to measure the participants' understanding of the observed changes, causes and future impacts of GCC (See Appendix F). The instrument was obtained by using two different sources.

The first source was a knowledge assessment scale for human-induced climate change (HICC) (human-induced climate change knowledge (HICCK); Lombardi et al., 2013). HICCK consisted of 27 items concerning the scientific consensus on observed changes and causes about HICC, and about common misconceptions about HICC. The items on scientific consensus were gathered from IPCC Fourth Assessment Report (2007), and the items about misconceptions were related to the misconceptions determined by Choi and his colleagues (2010). The Cronbach's alpha reliability value of the HICCK scale was obtained as 0.69 (Lombardi et al., 2013). For the understanding of GCC instrument, 16 items from HICCK were taken without making any change.

The second source for the understanding of GCC instrument was the IPCC Fifth Assessment Report (2014). The HICCK scale only included items about the observed changes and causes of HICC. In order to measure the participants' understanding of future risks and impacts 9 items were added from the future climate change, risks and impacts sections of the IPCC (2014). The focus of each item in the understanding of GCC instrument was presented in Table 7.

Table 7. Focus of Each Item in the Understanding of GCC Instrument

Focus	Items
The physical scientific aspects of the climate system	1 to 11
Causes of GCC	12 to 18
Predictions about future impacts of GCC	19 to 25

A climate expert and a science education expert examined the items of the understanding of GCC instrument for face and content validity. The added items were revised according to their comments by shortening some of the items without changing the meaning and by reversing some of the items. After the revisions, the first phase of data collection was carried out with the pilot sample in order to test the psychometric properties of the instrument.

The participants rated each item from a five-point Likert scale by deciding on how climate scientists would agree with each statement, ranging from 1 = strongly disagree to 5 = strongly agree. The possible minimum score was 25 and the possible maximum score was 125 for the instrument, where higher scores represented higher understanding of GCC. Cronbach's Alpha value of the instrument for the pilot sample of the current study was obtained as 0.83 (n = 109).

3.6.5 Degree of willingness to act scale

Boyes and his colleagues (2009) developed the Degree of Willingness to Act Scale to measure the intention of students to take pro-environmental actions (See Appendix G). The instrument was composed of 20 items: 12 related to direct actions, 4 related to indirect actions and 4 considered as incorrect in terms of GCC. The phrase "global warming" was used in place of "climate change" in this study in order to keep word formatting. The focus of each item in the instrument was presented in Table 8.

Table 8. Focus of Each Item in Degree of Willingness to Act Scale

Actions	Focus of interest	Item number
Direct Actions	Transport	1 – 14
	Power generation	2 – 13
	Domestic	3 – 6 – 16
	Personal	12 – 15
	Communal	7 – 8
Indirect Actions	Legislation	17
	Taxation	18
	Cooperation	19
	Education	20
	Unscientific	4 – 5 – 10 – 11

The participants rated each statement on a five-point Likert scale (1 = probably not and 5 = definitely). The possible minimum score was 20 and the possible maximum score was 80 for the instrument and higher scores indicated a higher tendency to undertake pro-environmental actions. The Cronbach's alpha reliability value of the instrument was obtained as 0.79 for the pilot sample of the current study (n = 80).

3.6.6 Need for cognition

Cacioppo and Petty (1982) created the Need for Cognition scale in order to assess individuals' dispositions to knowledge; in other words, to measure to what extent they "engage in and enjoy thinking" (p. 116). The original scale consisted of 32 statements, but it was revised and shortened to 18 items (Cacioppo et al., 1996) (See Appendix H). The Cronbach's alpha reliability value of the short version of the scale was obtained as 0.8 (Cacioppo et al., 1996).

The 18-item Need for Cognition scale is a five-point Likert scale from 1 = extremely uncharacteristic of me to 5 = extremely characteristic of me. The possible minimum score is 18 and the possible maximum score is 90 for the instrument. Individuals who have higher scores are likely to be able to willingly engage in thinking about cognitive activities, enjoy the thinking process and are willing to apply their thinking skills to the presented subject. Research on need for cognition revealed that these characteristics could be linked to the individuals' tendency to deal with social issues (Gregoire, 2003). The Cronbach's alpha value was 0.74 for the pilot sample of the current study (n = 109).

3.6.7 Need for closure

Webster and Kruglanski (1994) developed the Need for Closure scale to measure the epistemic motivation that investigates the tendency of an individual's motivation toward a decision or judgment (See Appendix I). The scale had 42 items originally but Roets and Van Hiel (2007) revised the items and shortened the instrument to 41 items. The results indicate that the psychometric properties of both versions are similar and the

short version can be used as a valid alternative tool for the need for closure construct. The Cronbach's alpha reliability values were .87 for the 42-item version and .79 for 41-item version. The scale is composed of 5 subscales: (a) preference for order and structure, (b) discomfort with ambiguity, (c) decisiveness in judgment and choices, (d) affording predictability to future contexts, and (e) closed-mindedness.

The items of the Need for Closure scale were scored on a six-point Likert scale, from 1 (strongly disagree) to 6 (strongly agree). The possible minimum score was 41 and the possible maximum score was 246 for the instrument, where higher scores implied a greater need for closure. A person rating high on need for closure is considered to be decisive, closed-minded and uncomfortable with ambiguity, prefers order and affords predictability to future contexts, whereas someone with a low need for closure can be creative and open to alternative explanations (Webster & Kruglanski, 1994). The Cronbach's alpha value was obtained as .76 for the pilot sample of the current study (n = 109).

3.7 Data analysis

After the data collection from the main sample, a number of statistical analyses were conducted to find answers to the research questions. In order to answer the first two research questions, descriptive statistics was used. For the third research question, Pearson's product moment correlation was used to investigate if there is a significant correlation between variables. Finally, for the final research question, multiple regression analysis was used to explore the predictors of the criterion variable.

CHAPTER 4

RESULTS

In this chapter, the results of the study are presented in three main sections. Firstly, descriptive statistics about pre-service teachers' (PST) plausibility perceptions and understanding of global climate change (GCC) are presented. Secondly, relationships between variables are introduced. Finally, the results of the predictors of criterion variables are revealed. Each result is also presented in the tables.

4.1 Descriptive statistics

4.1.1 Descriptive statistics regarding the variables of the study

Descriptive statistics related to the participants' plausibility perceptions and understanding of GCC, degree of willingness to act, need for cognition and need for closure scores are clarified in Table 9. The results showed that the participants' scores for the plausibility perceptions measure were $M = 60.41$ ($SD = 9.67$), for the understanding of GCC instrument were $M = 90.90$ ($SD = 7.68$), for degree of willingness to act were $M = 58.91$ ($SD = 8.55$), for need for cognition were $M = 61.34$ ($SD = 7.61$), and for need for closure were $M = 158.5$ ($SD = 20$).

Table 9. Descriptive Statistics Regarding the Variables of the Study

N_{Total} = 199	Mean	SD	Range	Skewness	Kurtosis	Cronbach's alpha
Plausibility Perceptions Measure	60.41	9.67	43	-.057	-.506	.84
Understanding of GCC Instrument	90.90	7.68	38	.341	-.141	.71
Degree of Willingness to Act Scale	58.91	8.55	47	-.211	.067	.80
Need for Cognition	61.34	7.61	42	.188	.020	.71
Need for Closure	158.5	20.00	127	-.221	.944	.85

The possible score range is 8-80 for the plausibility perceptions measure, 25-125 for understanding of the GCC instrument, 20-80 for the degree of willingness to act scale, 18–90 for the need for cognition, 41-246 for the need for closure

In particular, when giving understanding scores in percentages and considering 70% as adequate (Leeming, Dwyer, & Bracken, 1995), the participants who had a total score over 88 were considered as having an adequate understanding. According to the results, 63% of the participants had at least an adequate understanding of GCC. Regarding the degree of willingness to act, 61% of the participants were "almost certainly" and "definitely" willing to take the stated climate-friendly actions. Also, 42% of the participants showed they had a high need for cognition by having a score over 70% on the need for cognition scale. According to Webster and Kruglanski (1994) "participants scoring in the upper third of this distribution (score exceeding 166) were classified as high in dispositional need for closure, and those scoring in the lower third of the distribution (score below 148) were classified as low" (p. 1057). Hence, in this

study, 36% of the participants had a high need for closure and 28 % had a low need for closure. With this classification, 38% of the participants had a high preference for order, 53% had high discomfort with ambiguity, 43% had high decisiveness in judgment, 32% had high predictability to forthcoming situations, and 1% had a high closed-minded mindset.

4.1.2 PSTs' plausibility perceptions of global climate change

Research Question 1. What are PSTs' plausibility perceptions of GCC?

Participants' plausibility perceptions of GCC were measured by using Plausibility Perceptions Measure (PPM). Descriptive statistics were used to examine PPM scores of participants. Participants' PPM scores were normally distributed as shown in Figure 3. The distribution of the participants' total scores in PPM showed that 46 % of the participants rated over the mean (*M*=60.41, *SD*=9.666).

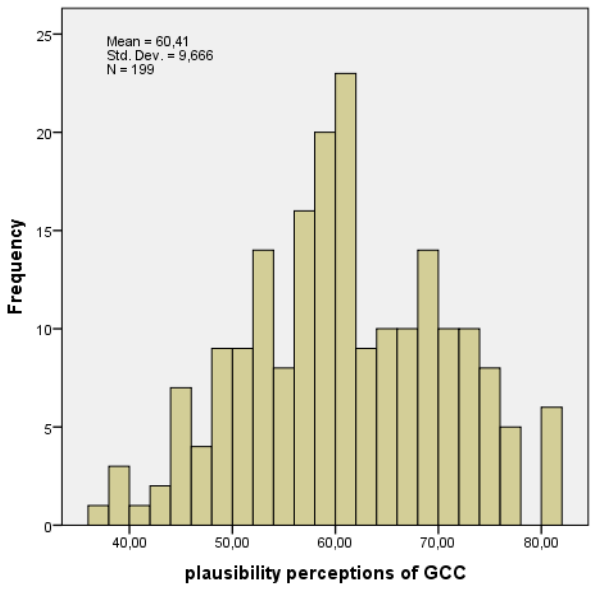


Figure 3 Histogram for participants' total PPM scores

Descriptive statistics was used to investigate participants' plausibility perceptions for each item in PPM. The means, standard deviations, highly plausible and greatly implausible percentages for each item in PPM are presented for the participants in Table 10.

Table 10. Descriptive Statistics of Each Item in PPM

Focus	Items	Mean	SD	Highly plausible (%) (rates 8-9-10)	Greatly implausible (%) (rates 1-2-3)
Evidences for GCC	Item 1	7.56	1.82	55	2
	Item 2	7.93	1.65	64	1
Evidences for supporting human link to GCC	Item 3	7.57	1.79	56	2
	Item 4	7.89	1.79	65	2
	Item 5	7.50	1.67	52	3
Predictions about future impacts of GCC	Item 6	7.83	1.64	65	2
	Item 7	6.53	1.90	33	6
	Item 8	7.61	1.78	57	2
	Total	7.55	1.77	56	3

Figure 4 presented the percentages of participants' responses for each item in the instrument. According to Figure 4, item 2, which focused on evidence for GCC with a mean score of 7.93; item 4, which focused on evidence for supporting the human link to

GCC with a mean score of 7.89; and item 6, which focused on predictions about future impacts of GCC with a mean score of 7.83, were rated as highly plausible (64, 65 and 65% respectively). Item 7, which also focused on predictions about future impacts of GCC with a mean score of 6.53, was rated as greatly implausible (6%).

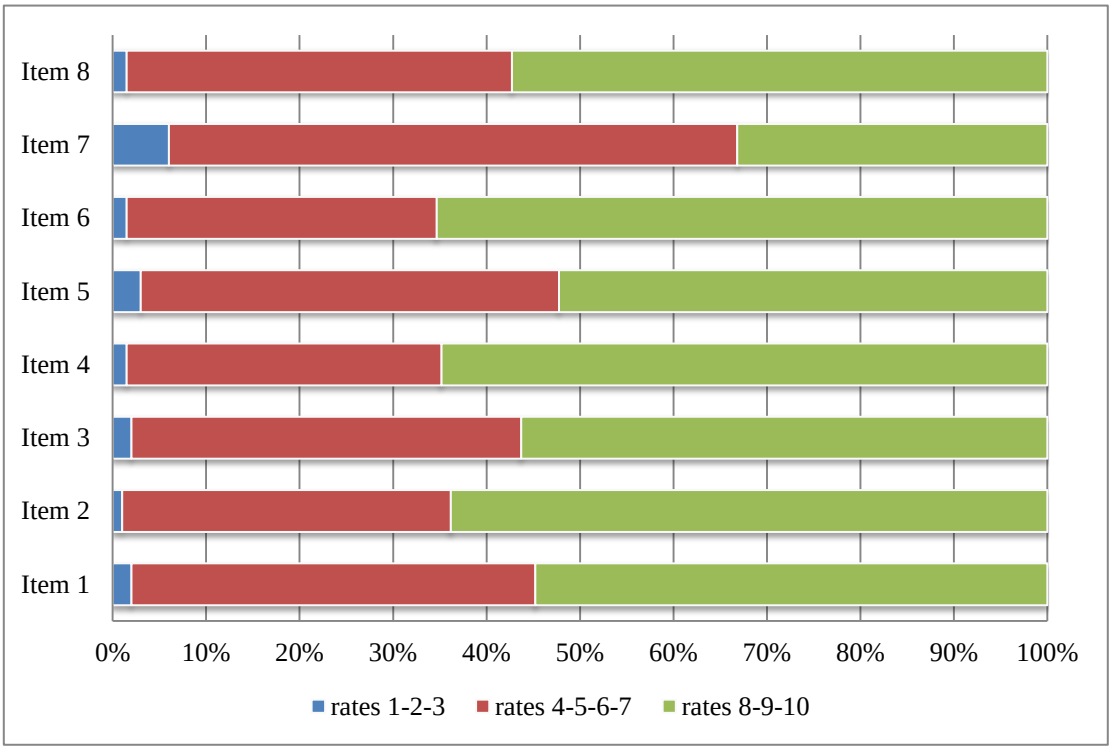


Figure 4 Percentages of participants' responses for each item in PPM

In particular, most of the participants found it plausible that humans are causing current climate change that this change is affecting the natural systems, and that it is going to be worse in the future with the continued emissions of carbon dioxide at or above the present amount. However, among eight items, most of the participants did not find it highly plausible that even if the stabilization of greenhouse gases is provided, there will be continued effects of climate change. These items are given Table 11.

Table 11. Highly Plausible and Greatly Implausible Items

Focus	Plausibility of the items	Item
Evidence for GCC	Highly plausible (64 %) Greatly implausible (1 %)	Item 2. Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.
Evidence for supporting human link to GCC	Highly plausible (65 %) Greatly implausible (2 %)	Item 4. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the increase in human-caused emissions of greenhouse gases, such as carbon dioxide.
Predictions about future impacts of GCC	Highly plausible (65 %) Greatly implausible (2 %)	Item 6. Continued emissions of carbon dioxide at or above current rates will cause further warming and induce many changes in the global climate during the 21st century that would probably be larger than those observed during the 20th century.
Predictions about future impacts of GCC	Highly plausible (33 %) Greatly implausible (6 %)	Item 7. Human caused climate change and sea level rise will continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations are stabilized at current levels.

4.1.3 PSTs' understanding of global climate change

Research Question 2. What is PSTs' understanding of GCC?

This research question was tested by Descriptive Statistics. The Understanding of GCC Instrument was used to measure participants' understanding of GCC. Descriptive statistics was used to examine the participants' understanding of GCC. The participants' understanding of GCC scores was approximately normal, as assessed by visual inspection of their histograms (see Figure 5) and by Shapiro-Wilk's test ($p < .05$). The distribution of the participants' total scores in understanding of GCC showed that 47.5% of the participants rated over the mean ($M = 90.91$, $SD = 7.685$).

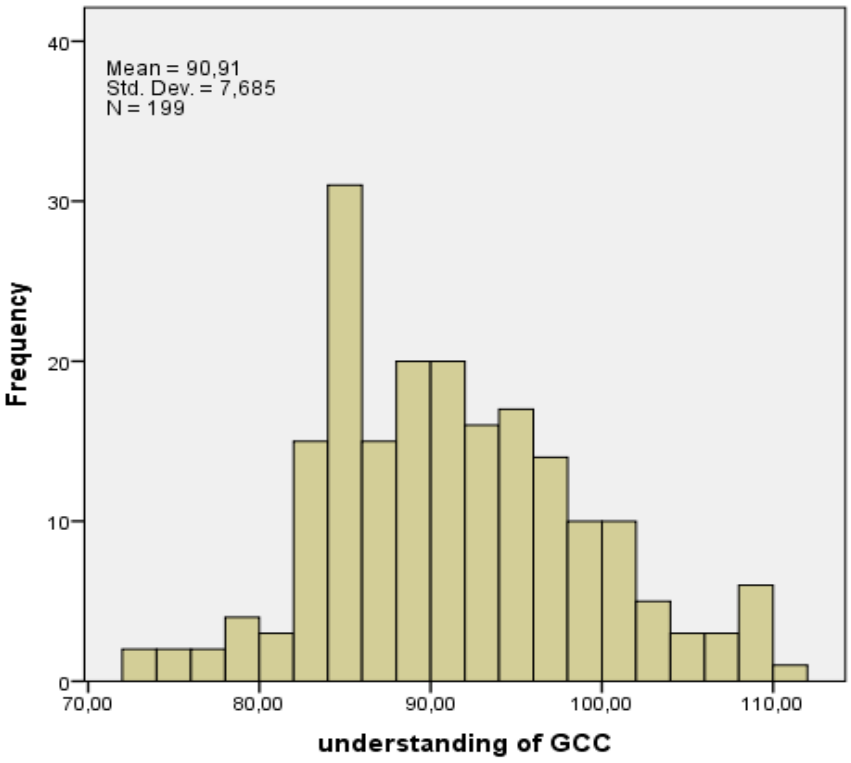


Figure 5 Histogram for participants' understanding of GCC

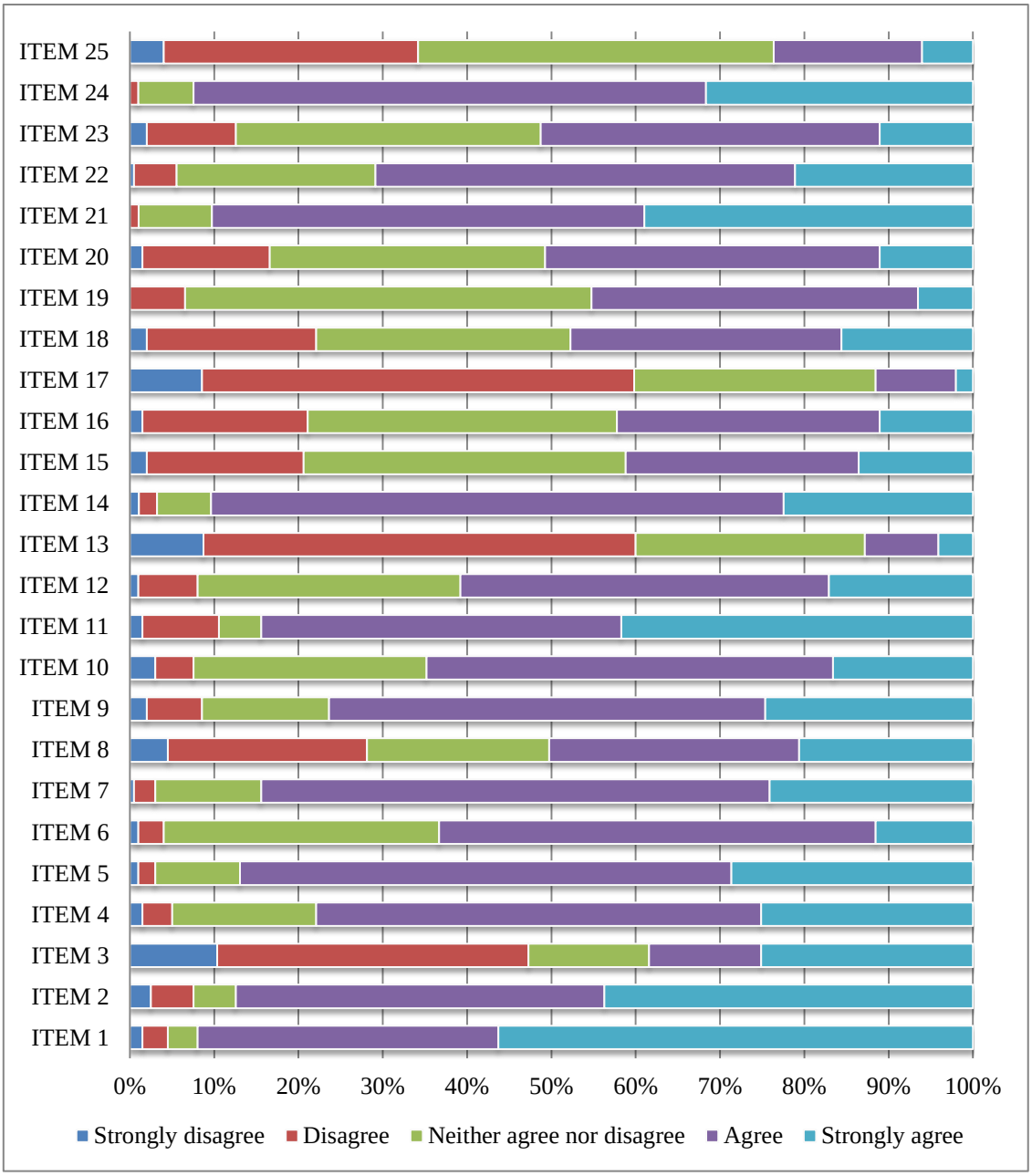
According to the analyses for each item in the understanding of GCC instrument, most of the participants obtained high mean scores from Understanding of GCC Instrument (see Table 12). According to Table 12, Item 1 and 21 had the highest mean scores (M = 4.42, SD = .824; M = 4.28, SD = .658 respectively), whereas Item 13 and 17 had the lowest mean scores (M = 2.47, SD = .914; M = 2.46, SD = .855 respectively).

Table 12. Descriptive Statistics on Participants' Scores for Each Item in Understanding GCC Instrument

Focus	Item	Mean	SD	Agree (%)	Disagree (%)
The physical scientific aspects of the climate system	Item 1	4.42	.824	92	5
	Item 2 *	4.21	.935	8	87
	Item 3 *	2.90	1.231	48	37
	Item 4	3.96	.837	78	5
	Item 5	4.12	.740	87	3
	Item 6	3.70	.751	63	4
	Item 7	4.05	.716	84	3
	Item 8 *	3.38	1.182	28	50
	Item 9	3.90	.913	76	9
	Item 10 *	3.71	.902	8	65
	Item 11 *	4.14	.975	11	84
Causes of GCC	Item 12 *	3.69	.872	8	60
	Item 13 *	2.47	.914	61	13
	Item 14	4.12	.683	90	3
	Item 15 *	3.32	.993	21	41
	Item 16 *	3.31	.960	21	42
	Item 17 *	2.46	.855	60	12
	Item 18 *	3.39	1.038	22	48
Predictions about future impacts of GCC	Item 19	3.46	.714	45	7
	Item 20 *	3.44	.928	17	51
	Item 21	4.28	.658	90	1
	Item 22	3.86	.823	71	6
	Item 23	3.48	.898	51	13
	Item 24	4.23	.608	92	1
	Item 25 *	2.91	.936	34	24

* represents the reversed items

Figure 6 presented the percentages of participants' responses for each item in the instrument. Regarding Figure 6, items with the highest rates on strongly agree and agree; strongly disagree and disagree; and participants' rates on the items that were related to common misconceptions are shown.



* Scores of the reversed items were reversed

Figure 6 Percentages of participants' responses for each item in Understanding GCC Instrument

As represented in the Figure 6, 92% of the participants said that climate scientists (strongly) agree with the statements in Item 1 and Item 24; 90% for Item 14 and Item 21. On the other hand, 87%, 84%, 65% and 60% of the participants stated that climate scientists (strongly) disagree with the statements in Item 2, 11, 10 and 12 respectively. Moreover, items 13, 15, 17 and 18 were common misconceptions (Choi et al., 2010). 60% of the participants stated that climate scientists (strongly) agree with the statements in Item 13 and Item 17; whereas this was 21% for item 15 and 22% for item 18. These items were given below in Table 13.

Table 13. Percentages of Items in Understanding of GCC Instrument

Agreement on items	Item	Percentage (%)
Items that the majority of the participants stated that climate scientists strongly agree or agree with	Item 1. The Sun is the main source of energy for Earth's climate.	92
	Item 14. Current climate change is caused by human activities.	90
	Item 21. Climate change will amplify existing risks and create new risks for natural and human systems.	90
	Item 24. Projected climate change will impact human health.	92
Items that the majority of the participants stated that climate scientists strongly disagree or disagree with	Item 2. Human has very little effect on Earth's climate.	87
	Item 11. Earth's climate is not currently changing.	84
Items with misconceptions	Item 13. Current climate change is caused by the ozone hole.	60
	Item 15. Current climate change is caused by changes in Earth's orbit around the Sun.	21
	Item 17. Current climate change is caused by increasing dust in the atmosphere.	60
	Item 18. Current climate change is caused by an increase in the Sun's energy.	22

4.2 Correlational analysis

Research Question 3. Is there a relationship between PSTs' plausibility perceptions and understanding of GCC?

The first two research questions of the study focused on the results of descriptive statistics of the variables and group comparisons of the participants. This research question investigated the correlations between the variables. Correlational analysis is a statistical technique that shows the degree of association between two variables. Pearson Correlation was used to determine the strength and the direction of the association between the variables. Before testing the hypothesis, firstly assumptions of Pearson Correlational Analysis were checked:

- Linearity: Pearson's correlation can be used if there is a linear relationship between two variables. Scatterplots shown in Figure 7 showed that there is a linear relationship between participants' plausibility perceptions and understanding of GCC.
- Outliers: Pearson's correlation analysis requires testing unusual points in the data set. These unusual points can be determined with the scatterplots that are used to test linearity. When checking the scatterplot in Figure 7, it can be said that there are no outliers in this data set.
- Normality: In order to examine the statistical significance of Pearson's correlation coefficient, there needs to be bivariate normality, in other words, both variables must be normally distributed. As shown in Figure 3, participants' PPM scores were normally distributed and as presented in Figure 5 understanding of GCC scores were approximately normally distributed.

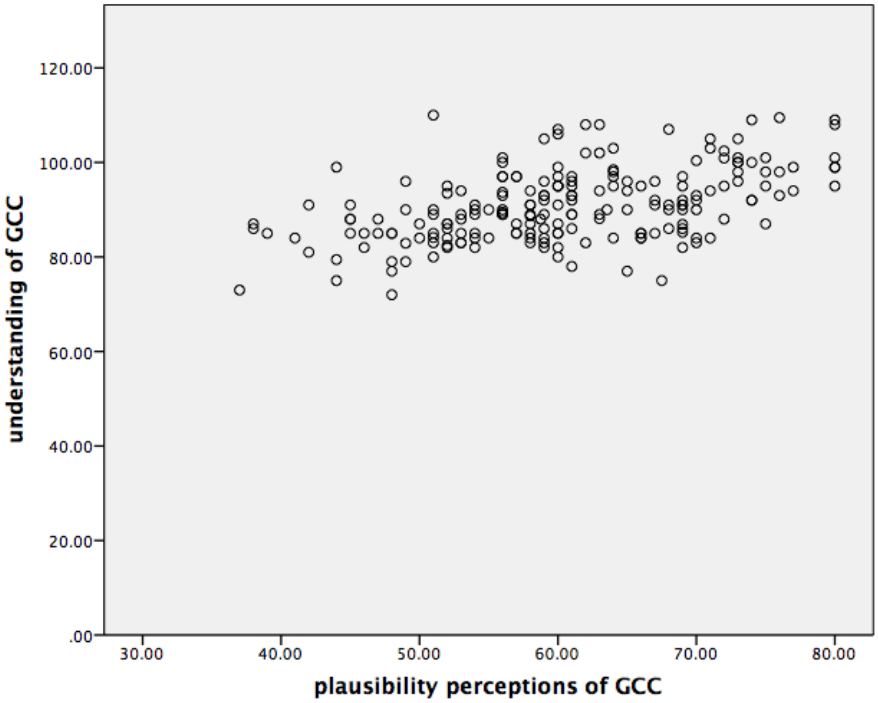


Figure 7 Scatterplots of variables

Preliminary analyses showed the relationship to be linear with both variables normally distributed, as assessed by the Shapiro-Wilk test ($p > .05$), and there were no outliers. A Pearson's Correlation Analysis was run to determine the strength and direction of a linear relationship between participants' plausibility perceptions and understanding of GCC. There was a moderate positive correlation between PSTs' plausibility perceptions and understanding of GCC, $r(197) = .491$, $p < .0005$. The correlation coefficient between variables was shown in Table 14.

Table 14. Correlation Coefficient between Plausibility Perceptions and Understanding of GCC

	Plausibility perceptions of GCC	Understanding of GCC
Plausibility perceptions of GCC	1	.491**
Understanding of GCC		1

** Correlation is significant at the 0.01 level (2-tailed).

4.3 Regression analysis

Research Question 4. Do understanding of GCC, degree of willingness to act, need for cognition, and need for closure predict PSTs' plausibility perceptions of GCC?

This research question was tested by stepwise multiple linear regression analysis. Multiple regression analysis is a statistical technique that aims at providing an explanation for the proportionate contribution of the predictor variables to the total variance of predicted variable. Stepwise multiple linear regression is a selective process that allows the constructing of regression models with statistically significant variables. Before testing the research question, firstly assumptions of multiple linear regression analysis were checked:

- Normality: In order to be able to run multiple regression analysis, the residuals need to be normally distributed. Figure 8 shows the histogram for the distribution of residuals (M = -1.99, SD = .990).

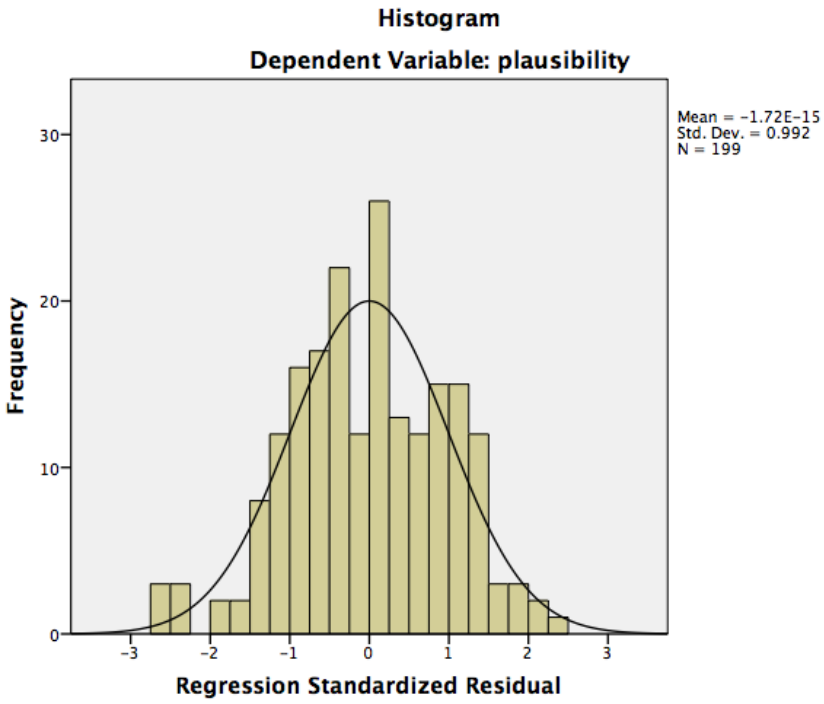


Figure 8 Histogram of residuals

- Linearity: Multiple regression analysis requires having a linear relation of each independent variable to the dependent variable and independent variables aggregately related to the dependent variable. In the Normal Probability Plot, the residuals present a reasonably straight relationship as shown in Figure 9.
- Homoscedasticity: The independent variables are supposed to have approximately equal values for each value of the predicted dependent variable. The assumption of homogeneity of variance can be tested by the scatterplots. The variables were almost equally spread. Therefore the homoscedasticity assumption is met.

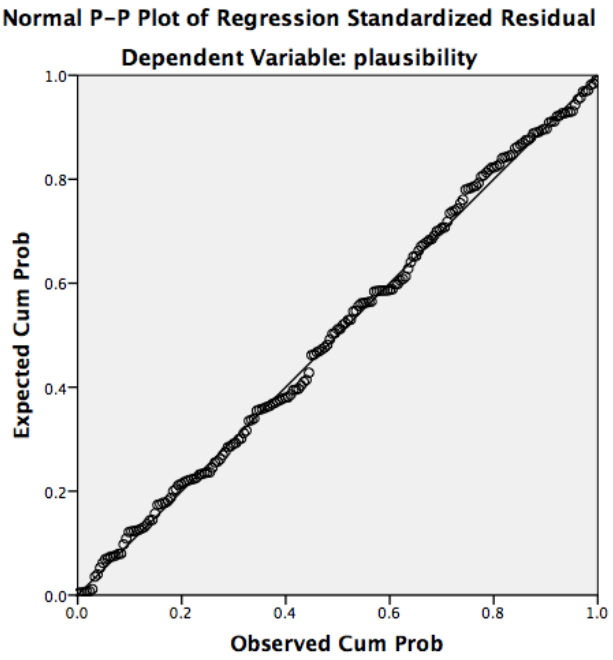


Figure 9 Normal probability plot for plausibility perceptions of GCC

- Outliers: Outliers are values that are distant from other values. The Case wise Diagnostics table determines the cases whose standardized residuals are greater than ±3 standard deviations. If the standardized residuals are less than ±3 standard deviations, this table will not be produced. In this study, outliers were removed before the analysis. Therefore, the outliers' assumption is met.
- Multicollinearity: The assumption of multicollinearity is met if two or more independent variables are not highly correlated with each other (r= .7 and below). Multicollinearity is tested by two stages: analysis of correlation coefficients and Tolerance values. The correlations between variables are presented in Table 15 and Tolerance values are shown in Table 16. Correlation coefficients between variables are not higher than .7 and Tolerance values are greater than .1. Therefore, the multicollinearity assumption is met.

Table 15. Correlations

Variables	1	2	3	4	5
1.Plausibility perceptions of GCC	1.00				
2.Understanding of GCC	.49**	1.00			
3. Degree of willingness to act	.31**	.19**	1.00		
4. Need for cognition	.22**	.23**	.18*	1.00	
5. Need for closure	.18*	.10	.04	-.13	1.00

** Correlation is significant at the 0.01 level, * correlation is significant at 0.05 level

Table 16. Tolerance Values of Variables

Variables	Tolerance
Understanding of GCC	.96
Degree of willingness to act	.96
Need for closure	.99

As presented in Table 15, there is a significant and moderate positive correlation between plausibility and understanding of GCC. There is also a significant and moderate positive correlation between plausibility and degree of willingness to act. Moreover, there is a significant and small correlation between plausibility and need for cognition. Further, there is a significant and small correlation between plausibility and need for closure.

A stepwise multiple regressions was run to predict participants' plausibility perceptions of GCC from understanding of GCC, degree of willingness to act, need for cognition and need for closure. The assumptions of normality, linearity, homoscedasticity, multicollinearity and unusual points were met. Among these variables, understanding of GCC, degree of willingness to act and need for closure statistically significantly predicted participants' plausibility perceptions, $F(3, 195) = 28.883$, $p < .0005$, adj. $R^2 = .31$. Altogether, understanding of GCC, degree of willingness to act and need for closure explained 31% of the variance in participants' plausibility perceptions of GCC ($p < .05$). The general form of the equation to predict plausibility perceptions of GCC from understanding of GCC, degree of willingness to act and need for closure is:

Predicted plausibility perceptions of GCC = -14.185 + (0.44 x understanding of GCC) + (0.23 x degree of willingness to act) + (0.13 x need for closure)

The standardized coefficient values, *Beta*, were used in the equation because Understanding of GCC Instrument and Degree of Willingness to Act were 5-point Likert scales, where Need for Closure was 6-point Likert scale. The *Beta* values for plausibility perceptions of GCC were .44 for understanding of GCC, .23 for degree of willingness to act and .13 for need for closure. Regression coefficients and standard errors can be found in Table 17.

Table 17. Summary of Multiple Regression Analysis

Variable	B	SE_B	*Beta*
Understanding of GCC	.55	.08	.44*
Degree of willingness to act	.26	.07	.23*
Need for closure	.06	.03	.13*

Note. * $p < .05$; β = unstandardized regression coefficient; SE_B = Standard error of the coefficient; Beta= standardized coefficient

Positive *Beta* values for the predictor variables; understanding of GCC, degree of willingness to act and need for closure imply that PSTs who have higher mean scores on plausibility perceptions also have higher mean scores on understanding of GCC, degree of willingness to act and need for closure. The model presenting the standardized values of the variables were shown in Figure 10.

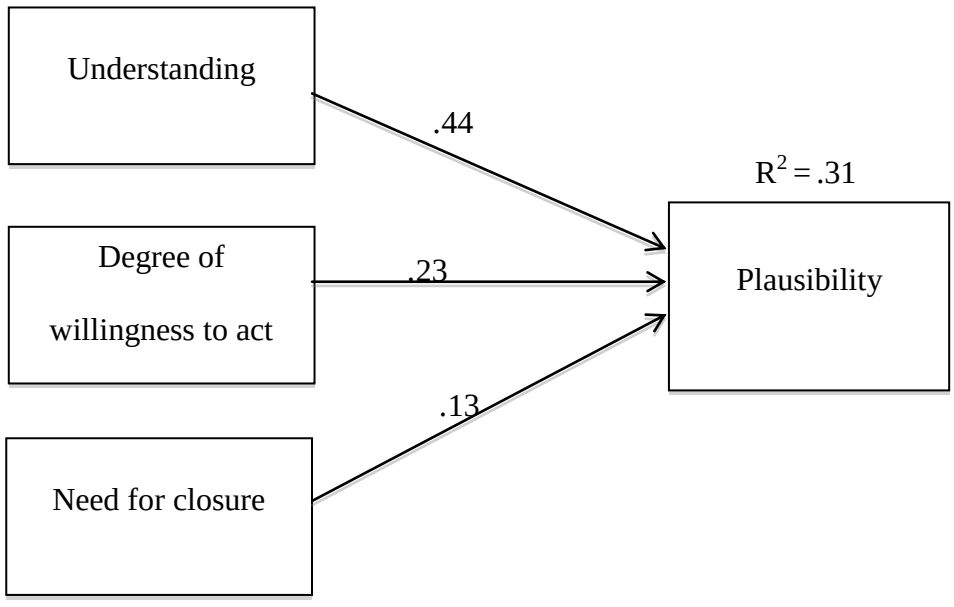


Figure 10 The model for the predictors of plausibility

4.4. Summary of the results

The summary of the results is as follows:

- Participants generally demonstrated high levels of plausibility.
- Most of the participants found it plausible that humans cause current climate change; this change is affecting the natural systems; and it is going to be worse in the future with the continued emissions of carbon dioxide at or above the present amount.
- Among eight items, participants did not find it highly plausible that even if the stabilization of greenhouse gases is provided, there will be continued effects of climate change.
- Participants generally demonstrated high levels of understanding of GCC.
- The majority of the participants stated that climate scientists strongly agree or agree with the statements “The Sun is the main source of energy for Earth’s climate”, “Climate change will amplify existing risks and create new risks for natural and human systems”, “Current climate change is caused by human activities” and “Projected climate change will impact human health”.
- Most of the participants stated that climate scientists strongly disagree or disagree with the statements “Humans have very little effect on Earth’s climate” and “Earth’s climate is not currently changing”.
- Most of the participants had misconceptions about the cause of current climate change by claiming, “Current climate change is caused by the ozone hole” or “Current climate change is caused by increasing dust in the atmosphere”.
- There is a significant positive correlation between plausibility perceptions and understanding of GCC.

- Understanding of GCC, degree of willingness to act and need for closure explained 31% of the variance in participants' plausibility perceptions of GCC.
- Understanding of GCC had the largest contribution in explaining the variance in participants' plausibility perceptions of GCC.

CHAPTER 5

DISCUSSION

In this chapter, the results of the study are discussed in the light of the literature. Firstly, the summary of the study is given to provide an insight into the whole study. Then, the next sections are discussions of the results of each research question. Finally, the limitations and implications of the study are explained in the last section of the chapter.

5.1 Summary of the study

The current study was conducted in a survey research design with 199 participants in the Department of Education of a public university in Turkey. The study aimed to investigate pre-service teachers' (PSTs) plausibility perceptions and understanding of global climate change (GCC). Specifically, the role of PSTs' cognitive, behavioral and personal characteristics on their plausibility perceptions of GCC was examined in this study. Five instruments were used to collect data. These are: Plausibility Perceptions Measure, Understanding of GCC Instrument, Degree of Willingness to Act Scale, Need for Cognition Scale and Need for Closure Scale.

A pilot study was conducted with 109 participants to test the psychometric properties of the instruments in the 2014 fall semester and the main study was conducted with 199 participants in the 2015 spring semester. Descriptive, correlational and regression analyses were conducted to answer the research questions.

The findings of the study revealed that PSTs have high plausibility perceptions and understanding of GCC. However, common misconceptions were found among PSTs. As another finding, there was a moderate positive correlation between PSTs' plausibility perceptions and understanding of GCC. The results of the multiple regression analysis revealed that understanding of GCC, degree of willingness to act and need for closure statistically significantly predict PSTs' plausibility perceptions of GCC.

5.2 Discussion of the results

In this section, firstly the participants' plausibility perceptions of GCC results were discussed in accordance with the literature. Secondly, the discussion about the participants' understanding of GCC was presented. Thirdly, the relationship between the participants' plausibility perceptions and understanding of GCC was discussed. Finally, the role of understanding of GCC, degree of willingness to act and disposition toward knowledge on plausibility perceptions of GCC was discussed.

5.2.1 PSTs' plausibility perceptions of global climate change

Plausibility is a status construct of conceptual change (Posner et al., 1982) that requires making cognitive judgments (Dole & Sinatra, 1998) in explaining the extent of the judgments (Lombardi et al., 2016). Regarding the purpose of the present study, the focus was on PSTs' plausibility perceptions of GCC and conceptual change was not tested.

The results of the descriptive analyses revealed that the mean score of PSTs' Plausibility Perceptions Measure (PPM) was M=60.41, SD=9.666. The possible

minimum score was 8 and the possible maximum score was 80 for the instrument, where higher scores represented higher plausibility. PSTs' PPM scores were normally distributed and 46% of the participants rated over the mean. Therefore, PSTs can be considered as having high plausibility perceptions of GCC. In particular, PSTs mainly found the items on evidences for GCC, evidences supporting human link to GCC and predictions about future impacts of GCC plausible or highly plausible.

The results of the study also showed that the mean score for each item was high (M = 7.55, SD = 1.76). For instance, most of the participants found it highly plausible that the current increase in global temperature results from human-caused emissions of carbon dioxide that it is affecting many natural systems and is going to cause further warming with continued emissions of carbon dioxide. Lombardi and his colleagues (2016) argued that the high plausibility of the statements might be because of the consistency of the given information with the participants' existing knowledge. Moreover, high plausibility perceptions of PSTs can be considered promising because it can be said that most of the participants can make cognitive judgments on the cause and some of the consequences of the current GCC.

On the other hand, most of the participants found it moderately plausible that climate change and sea level rise is going to continue even after stabilizing greenhouse gas concentrations at current levels. In other words, most of the participants could not make an expected prediction about one of the main future impacts of GCC. This result may be caused due to (1) the complex nature of the global climate, and (2) the difficulty in comprehending the feedback effects of the related mechanisms, both of which may result in an implausible judgment (Lombardi et al., 2016). This result also supported the

report of Connell and Keane (2006) that when the complexity of connections between related information increases, plausibility decreases.

Moreover, this result is consistent with the study of Sterman and Sweeney (2007). The essential relationship between flow and stock of greenhouse gases in the atmosphere was investigated with 212 undergraduate and graduate students. Sterman and Sweeney (2007) reported that "more than half violate the most basic stock-flow relationships" (p. 234) by not being able to apply their knowledge on "violation of conservation principles" (p. 234) or not having that knowledge at all. Lack of knowledge or having weak knowledge on stocks and flows may be crucial in participants' understanding of GCC and their willingness to take climate friendly actions (Sterman & Sweeney, 2007).

5.2.2 PSTs' understanding of global climate change

Descriptive analysis for PSTs' understanding of GCC showed that the mean score of PSTs on the understanding of GCC instrument was $M = 90.91$, $SD = 7.685$. The possible minimum score was 25 and the possible maximum score was 125 for the instrument, where higher scores represented higher understanding of GCC. The PSTs' scores were approximately normally distributed and 47.5 % of the participants rated over the mean. The PSTs can be considered as having a high understanding of GCC with a high mean score. The results of the study also revealed that the majority of the participants had sufficient knowledge about the reason for the current GCC, that it is caused by human activities, and that some of the projected results that climate change will amplify

existing risks, create new risks for natural and human systems, and projected climate change will impact human health.

Contrary to the results of the present study, some research findings reported the participants' lack of understanding (e.g. Arslan et al., 2012). For instance, Arslan and her colleagues (2012) conducted research with 256 PSTs in the US by using a diagnostic test to evaluate PSTs' understanding and determine their misconceptions. Arslan and her colleagues (2012) reported that the majority of the PSTs had limited conceptual understanding about climate related concepts.

On the other hand, Bozdogan and Yanar (2010), who conducted research with 68 elementary PSTs in Turkey to investigate their perceptions on the effects of GCC in the next century, stated that almost all of the participants had an adequate knowledge in the future predictions of GCC. In another study, Danielson and Lombardi (2015) examined "the relationship between GDP (i.e. gross domestic product), science literacy, and acceptance of human-induced climate change" (p. 13). The participants were individuals whose ages were between 18 and 34 from twenty-six countries. Danielson and Lombardi (2015) reported that 70% of the participants from Turkey answered, "Yes" to the statement "Temperature rise is part of global warming or climate change. Do you think rising temperatures are a result of human activities?" (p. 18). Moreover, considering the study context of the current study, which is a university that has high-achieving students, a climate center and several elective courses about climate, having high understanding of GCC is an expected finding for the current sample.

Another important finding of the study concerns PSTs' misconceptions about GCC. The results of the descriptive statistics showed that most of the PSTs had misconceptions that current climate change is caused by the ozone hole and increasing

dust in the atmosphere. These findings about PSTs' misconceptions were in accordance with other related studies (Feierabend et al., 2010; Kahraman et al., 2008; Kalipci et al., 2009; Khalid, 2001, 2003; Oluk & Oluk, 2007; Papadimitriou, 2004). For example, Kahraman and his colleagues (2008) stated that Turkish PSTs have some misunderstandings about the causes and the consequences of GCC. The present finding about the misconceptions of PSTs suggested that even if the participants were from a high-achieving university, studying in different fields, and had sufficient understanding of GCC, unexpectedly they had similar misconceptions to participants from previous studies in different contexts. Thus, the current findings revealed the necessity of focusing on finding ways to decrease misconceptions about GCC among PSTs.

Literature about middle school and high school students' understanding of GCC also shows that they have similar misconceptions (Boyes & Stanisstreet, 1997; Ozdem et al., 2014; Pruneau et al., 2003). The similarity of the misconceptions about GCC between students and PSTs may be because PSTs may lack some fundamental knowledge. PSTs' perceptions may also influence their students' viewpoints when they become teachers (Barba & Rubba, 1992). It follows that more studies need to be conducted concerning PSTs' misconceptions about GCC and accordingly there is a need for more research on improving teacher education programs concerning GCC education.

5.2.3 The relationship between PSTs' plausibility perceptions and understanding of GCC

Results of the correlational analysis revealed that there is a significant, moderate and positive correlation between PSTs' plausibility perceptions and understanding of GCC

($r(197) = .491$, $p < .05$). This result supported the previous findings, which showed a positive correlation between plausibility and understanding of GCC among middle school students (Lombardi et al., 2013) and college students (Lombardi & Sinatra, 2012; Lombardi et al., 2014; Lombardi et al., 2016). Different measures were used in these studies to examine the (3) participants' conceptions of the current scientific consensus about GCC such as; (1) understanding of distinctions between weather and climate, (2) knowledge about deep time (Lombardi & Sinatra, 2012), and (3) knowledge about the human-induced climate change instrument (Lombardi et al., 2014).

However, in another study conducted with PSTs and in-service teachers, knowledge of weather and climate distinctions did not predict plausibility (Lombardi & Sinatra, 2013). This result might have been obtained because a specific topic in GCC (weather and climate distinction) may not be enough to develop plausible perceptions. Moreover, PPM included actual statements from the IPCC report and the IPCC report does not have strong findings and connections about weather and climate distinctions. Therefore, knowledge of weather and climate distinctions instrument may be disconnected from what PPM measures.

With the current study, significant correlation between plausibility and understanding of GCC was provided. Considering the conceptual change framework, the relationship between plausibility and understanding is crucial. As hypothesized theoretically in conceptual change models, conceptions must be plausible for conceptual understanding of complex scientific issues like GCC (Lombardi et al., 2016). The current study empirically found that a higher value of plausibility is associated with greater understanding.

5.2.4 The role of understanding of GCC, degree of willingness to act and disposition toward knowledge on plausibility perceptions of GCC

Multiple regression analysis provides an explanation for the direction and degree of the relationships between the criterion and the predictor variables. Multiple regression analysis was conducted to examine the proportionate contribution of the cognitive, behavioral and personal variables to the total variance of plausibility. In other words, regression analysis investigated the role of understanding of GCC, degree of willingness to act, need for cognition, and need for closure on PST's plausibility perceptions of GCC. The findings of the regression analysis revealed that understanding of GCC, degree of willingness to act and preference for order were significant predictors of plausibility. These predictor variables explained 31% of the variance in PSTs' plausibility perceptions of GCC where cognitive and behavioral variables had more contribution to PSTs' plausibility perceptions of GCC. However, one of the personal variables in the study, need for cognition, did not predict plausibility.

In particular, in the regression model the cognitive variable has the largest contribution in explaining the variance in PSTs' plausibility perceptions of GCC. This result supported the theoretical literature in two ways. First, previous studies also presumed the association between plausibility and understanding (Dole & Sinatra, 1998; Lombardi et al., 2016; Posner et al., 1982). Second, research suggested the comprehension of a concept in a plausible way through cognitive engagement and conceptual understanding (Pintrich et al., 1993). Accordingly, the regression model in the current study revealed the biggest contribution to PSTs' understanding in their plausibility perceptions of GCC.

The second largest contribution in the regression model for the variance in the PSTs' plausibility perceptions of GCC was the behavioral variable, which included specific actions for reducing the influences of GCC. This result is promising because increase in the degree of willingness to take climate friendly actions explained the significant increase in the PSTs' plausibility perceptions of GCC. Namely, change in behavior contributed to the change in the plausibility perceptions, which can promote conceptual change through knowledge reconstruction (Dole & Sinatra, 1998).

The last predictor variables in the regression model were personal variables, which were subject independent and which aimed at explaining the need for cognition and the need for closure levels of the participants. The model showed that need for closure, one of the personal variables, predicted the PSTs' plausibility perceptions of GCC. Nevertheless, need for closure had the smallest contribution in the variance of the PSTs' plausibility perceptions of GCC. This contribution may be explained by two reasons: the need for closure is a subject independent scale and the participants in the current study had a high understanding of GCC. Webster and Kruglanski (1994) stated that a high need for closure refers to individuals who have structured inclinations in their lives, are not open to new and alternative explanations, and feel discomfort in ambiguous situations (e.g. these individuals may strongly agree with the statements such as "I enjoy having a clear and structured mode of life" or "I don't like situations that are uncertain"). These individuals may tend to believe in structured explanations and may find the information given in the explanation plausible. For instance, individuals with a high need for closure may find a climate model structured enough to develop plausible perceptions.

The other personal variable, the need for cognition, did not predict plausibility and had a low correlation with plausibility perceptions of GCC. Although need for cognition is considered as a determinant of taking pleasure in thinking and as GCC is a complex socio-scientific issue, parallel with a study in the literature, need for cognition did not predict plausibility (Lombardi et at., 2013). Research suggests that one factor for change in conceptual understanding may be "engaging in any extensive cognitive work relevant to the issue" (Cacioppo & Petty, 1982, p. 130). Nonetheless, in the current study participants did not experience a displeasure that may lead them to think critically (Cacioppo et al., 1996) and evaluate the intensity of their plausible perceptions. Additionally, need for cognition was a subject independent scale and with the current finding it can be assumed that the PSTs did not associate GCC with their intention to think critically on general complex cognitive issues.

5.3 Implications of the study

This study presented significant implications for PST educators, curriculum developers, environmental educators and climate change educators in particular. Several researchers theoretically or empirically have investigated conceptual change models in education (e.g. Dole & Sinatra; 1998; Posner et al., 1982; Treagust & Duit, 2008) and much research has pointed out the importance of plausibility in conceptual change, which mainly focuses on learners' ideas and their reasons for those ideas (e.g. Dole & Sinatra, 1998; Lombardi et al., 2016). In particular, socio-scientific issues (SSI) like GCC require critical evaluation (Lombardi & Sinatra, 2012; Sadler, Chambers, & Zeidler,

2006). The plausibility perceptions of learners gain importance in not only advancing their conceptual understanding but also changing their behavior (Sinatra et al., 2012).

In addition, learners' understanding of the nature of science and their scientific literacy may increase while evaluating a SSI (Sadler et al., 2006). GCC is considered as a crucial controversial topic in a SSI that requires a deep understanding process (Pintrich et al., 1993). In this sense, teachers play an important role in the learning process of GCC. Simmons and Zeidler (2003) claim that teachers need to have the necessary understanding about the topic that allows them to make argumentative evaluations in a social and scientific perspective. Therefore, teacher education programs should place importance on PSTs' understanding of controversial issues that may influence their instruction (Oluk & Oluk, 2007). As revealed with the current study and supported by the literature, the possible increase in the plausibility perceptions of PSTs may be associated with higher understanding and more climate-friendly actions (Sinatra et al., 2012). Thus, providing critically evaluative and climate-friendly environments to PSTs may promote their plausibility perceptions toward a more scientific stance.

Results of the current study also suggested that there are differences in PSTs' levels of need for closure, which had a small contribution to PSTs' plausibility perceptions. Thus, teacher education programs may consider the individual characteristics of PSTs. Teacher education coursework may include courses that provide opportunities for PSTs to take part in discussions and improve critical thinking especially towards a SSI like GCC. Conjointly, in order to increase PSTs' plausibility perceptions of GCC, teacher education programs may also focus on how to make PSTs think critically and make evaluations for alternative explanations by considering cognitive, behavioral and personal variables.

5.4 Limitations and suggestions

In this section, the limitations of the study were presented and some possible suggestions were revealed. The first limitation concerned generalizability. As convenient sampling was used to determine the participants of the current study, the results may not be generalized to all PSTs in Turkey. In particular, the current study was limited to one public university in Turkey, which is a selective university in terms of accepting the highest scored students from the national exam for the Faculty of Education. In order to generalize the results for all Turkish PSTs, the study can be conducted with participants from a larger sample in other universities.

The second limitation concerned the amount of time spent in data collection and the language of the instruments. Implementation of the instruments took about 30-45 minutes, which may be tiring for some of the participants. The instruments were implemented in English even though all of the participants were Turkish. The implementation time and language might be a limitation, but the instructional language of the university is English, so the participants were expected to comprehend the statements of the instruments. Besides, a pilot study was conducted to test the psychometric properties of the instruments, to observe the implementation time and predict possible problems. The researcher was present in the classroom during the implementation process both in the pilot and the main study to give a brief explanation and answer the participants' questions if any. The reliability results were convincing and there was no missing data affecting the data analysis. For further studies, the instruments may be translated into Turkish and implemented with a different sample in Turkey.

The third limitation concerned the representation of participants' actual opinions in their responses. In other words, for need for cognition, need for closure, or

willingness to take climate friendly actions, participants might have given socially agreeable and commonly expected responses (Sinatra et al., 2012). However, agreeable responses would not explain the impact of the predictor variables on the participants' plausibility perceptions. Additionally, willing to act does not always result in actual behavior. Further studies are needed to investigate the participants' actual behavior in detail. As an alternative, a longitudinal study may be conducted to investigate the role of personal characteristics and the actual behavior of participants on their plausibility perceptions.

The last limitation concerned the subject of the study. GCC was determined as the subject of the study and the findings were limited to PSTs' plausibility perceptions of GCC. Further research may investigate PSTs' plausibility perceptions of different SSI and ascertain the possible determinants of plausibility in different issues to create a strong conceptual change.

APPENDIX A

BOXPLOT RESULTS

Boxplot results for Understanding of GCC Instrument and Plausibility Perceptions Measure are presented below to show the distribution of the data and to detect outliers:

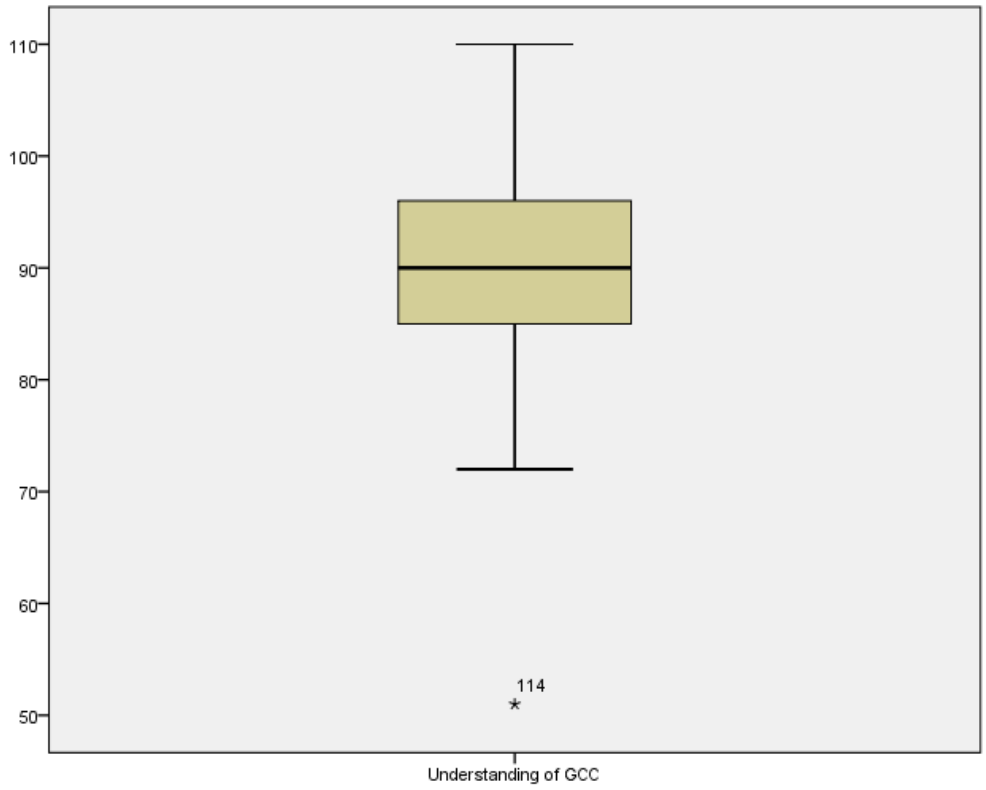


Figure 11 Boxplot results for understanding of GCC

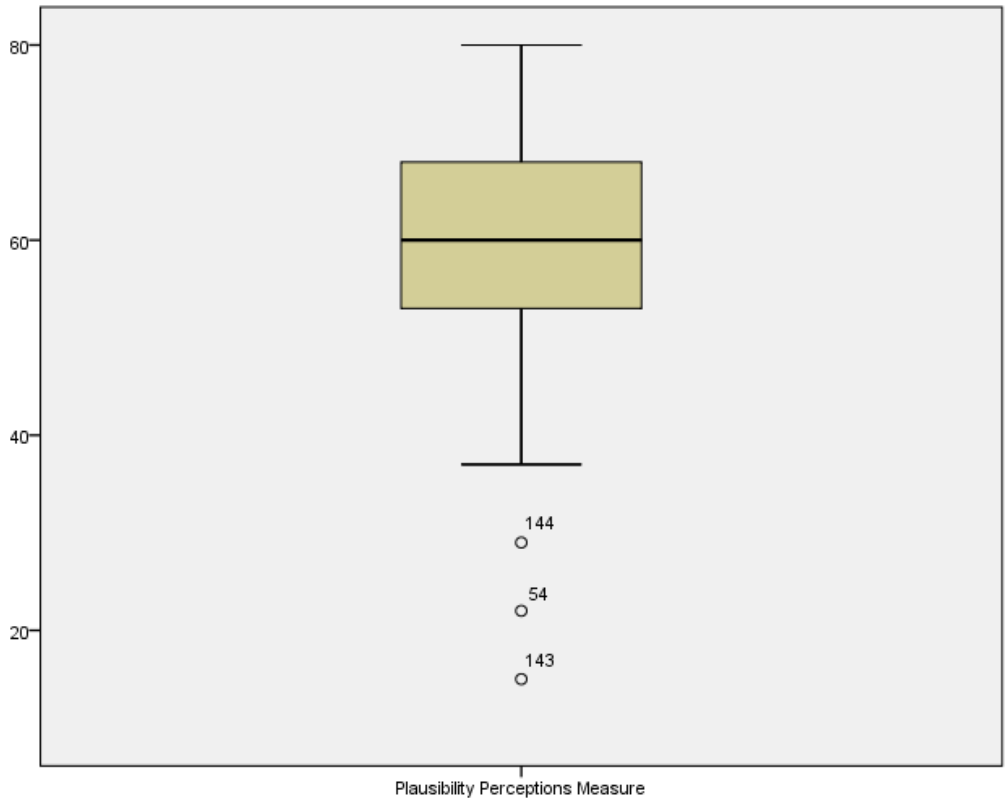


Figure 12 Boxplot results for PPM

APPENDIX B

ETHICS COMMITTEE REPORT

BOĞAZİÇİ ÜNİVERSİTESİ
İnsan Araştırmaları Kurumsal Değerlendirme Kurulu (İNAREK) Toplantı Tutanağı
2015/02
EK

20.04.2015

Gaye Defne Ceyhan
Boğaziçi Üniversitesi Kuzey Kampüs ETA B Blok İlköğretim Bölümü Oda: 416 Bebek/ İstanbul
gaye.ceyhan@boun.edu.tr

Sayın Araştırmacı,

"Öğretmen Adaylarının Küresel İklim Değişikliği Akla Yatkınlık Algıları: Bilişsel, Davranışsal ve Kişisel Değişkenlerin Etkisi" başlıklı projeniz ile yaptığınız Boğaziçi Üniversitesi İnsan Araştırmaları Kurumsal Değerlendirme Kurulu (İNAREK) 2015/38 kayıt numaralı başvuru 20.04.2015 tarihli ve 2015/02 sayılı kurul toplantısında incelenerek etik onay verilmesi uygun bulunmuştur.

Saygılarımızla,

Prof. Dr. Hande Çağlayan (Başkan)
Moleküler Biyoloji ve Genetik Bölümü,
Fen-Edebiyat Fakültesi, Boğaziçi Üniversitesi,
İstanbul

Yrd. Doç. Dr. Özgür Kocatürk
Biyo-Medikal Mühendisliği Enstitüsü
Boğaziçi Üniversitesi,
İstanbul

Prof. Dr. Yeşim Atamer
İstanbul Bilgi Üniversitesi
Hukuk Fakültesi
İstanbul

Doç. Dr. Özlem Hesapçı
İktisadi ve İdari Bilimler Fakültesi,
İşletme Bölümü, Boğaziçi Üniversitesi,
İstanbul

Yrd. Doç. Dr. Ekin Eremsoy
Psikoloji Bölümü, Doğuş Üniversitesi,
İstanbul

APPENDIX C

CONSENT FORM

İklim değişikliği konusundaki düşünceleriniz bizim için çok önemlidir. Bu sebeple, iklim değişikliği konusundaki görüşlerinizi anlamak için bu ölçeği doldurmanızı rica ederiz.

Gaye Defne Ceyhan

Araştırma Görevlisi

Onay Bildirimi: Bu araştırmada toplanan veriler gizli tutulacaktır. Araştırmanın sonuçları akademik amaçlar için kullanılacaktır ve verdiğim cevapların notlarım üzerinde herhangi bir etkisi olmayacaktır. Toplanan bilgiler şahsi bilgilerim paylaşılmadan, araştırma sonuçlarını yorumlamada ve bu araştırma kapsamından düzenlenecek olan çalışmalarda kullanılacaktır.Araştırmanın amaçlarını ve prosedürleri netleştirmek için sorular sorabilirim.Araştırmadan istediğim zaman ayrılabilirim. Araştırmanın amacı konusunda bilgilendirildim ve gönüllü olarak katılmayı kabul ediyorum.

Katılımcının Adı-Soyadı: _____

İmza: _____

Tarih: _____

APPENDIX D

DEMOGRAPHIC FORM

The aim of the following survey is to understand your view about global climate change. The survey is supposed to take about 30 minutes. The results will be used for thesis research. There is no correct answer and your answers will be kept anonymous. Thank you so much for your valuable time.

1. Gender

a) Female b) Male

2. Hometown (the place you grew up)

a) Rural area b) Small town (25.000-100.000) c) Big city (more than 100.000)

3. Your major field of study

a) Foreign Language Education b) Preschool Education

c) Primary Mathematics Education d) Primary Science Education

e) Secondary Chemistry Education f) Secondary Mathematics Education

g) Secondary Physics Education

4. Have you ever taken a course about environmental education?

a) Yes b) No

If yes, please indicate the name(s)/code(s) of the course(s):……

5. Do you belong to, or have you ever belonged to an environmental organization or group?

a) Yes b) No

If yes, please indicate the name(s) of the organization(s):……

APPENDIX E

PLAUSIBILITY PERCEPTIONS MEASURE

Read the following statements. Rate the plausibility on a scale from 1 to 10: 1 being greatly implausible (or even impossible) and 10 being highly plausible. Try to use the full range of numbers in your responses.

1. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

---

2. Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

---

3. Worldwide concentrations of atmospheric greenhouse gases, such as carbon dioxide, have increased markedly as a result of human activities since 1750 and now far exceed preindustrial values determined from ice cores spanning many thousands of years.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

4. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the increase in human-caused emissions of greenhouse gases, such as carbon dioxide.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

5. Human influences on climate extend beyond average global temperature to other aspects, such as rising sea levels and widespread melting of snow and ice.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

6. Continued emissions of carbon dioxide at or above current rates will cause further warming and induce many changes in the global climate during the 21st century that would probably be larger than those observed during the 20th century.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

---

7. Human caused climate change and sea level rise will continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations are stabilized at current levels.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

---

8. Human caused climate change will lead to some impacts that are abrupt or irreversible, such as massive polar ice melt.

Greatly implausible 1 2 3 4 5 6 7 8 9 Highly plausible 10

APPENDIX F

UNDERSTANDING OF CLIMATE CHANGE INSTRUMENT

Below are statements about climate change. Rate the degree to which you think that *climate scientists* agree with these statements. Please rate according to the following scale: 1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
Statements	1	2	3	4	5
*1. The Sun is the main source of energy for Earth's climate.					
*2. Human has very little effect on Earth's climate.					
*3. Earth's climate has probably changed little in the past.					
*4. Burning of fossil fuels produces greenhouse gases.					
*5. Greenhouse gas levels are increasing in the atmosphere.					
*6. Greenhouse gases absorb some of the energy emitted by Earth's surface.					
**7. Many species have shifted their seasonal activities, migration patterns in response to ongoing climate change.					
**8. Glaciers have continued to expand almost worldwide.					
*9. Average sea level is increasing.					
*10. We cannot know about ancient climate change.					

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
Statements	1	2	3	4	5
*11. Earth's climate is not currently changing.					
*12. Current climate change can only be explained by natural fluctuation.					
*13. Current climate change is caused by the ozone hole.					
*14. Current climate change is caused by human activities.					
*15. Current climate change is caused by changes in Earth's orbit around the Sun.					
*16. Current climate change is caused by volcanic eruptions.					
*17. Current climate change is caused by increasing dust in the atmosphere.					
*18. Current climate change is caused by an increase in the Sun's energy.					
**19. Heat waves will occur more often and last longer.					
**20. Extreme events will become less intense and less frequent in many regions.					
**21. Climate change will amplify existing risks and create new risks for natural and human systems.					
**22. Coastal and low-lying areas are at risk from sea-level rise.					
**23. Climate change is projected to undermine food security.					
**24. Projected climate change will impact human health.					
**25. Climate change is projected to decrease displacement of people.					

* represents items taken from HICCK instrument (Lombardi et al., 2013)

** represents items obtained by IPCC Fifth Assessment Report (2014)

APPENDIX G

DEGREE OF WILLINGNESS TO ACT SCALE

Below are statements about how likely you are to undertake action for climate change. Rate the degree to how much you agree with these statements. Please rate according to the following scale:

1: probably not 2: perhaps 3: probably 4: almost certainly 5: definitely

	Probably not	Perhaps	Probably	Almost certainly	Deninitely
Statements	1	2	3	4	5
1. Even if it was not as fast or luxurious, I would try to get a car that uses less petrol or less diesel.					
2. Providing more of our energy was produced from nuclear power stations, I would be willing to pay more for electricity.					
3. Even though it cost me money, I would make changes to my home to stop so much heat escaping.					
4. Even if it was more trouble for me, I would not drop litter in the streets.					
5. Even if it was more expensive, I would buy food grown without the use of pesticides (sprays that kill the insects that damage plants).					
6. To save electricity, I would switch things off at home when I didn't need them.					
7. Even if I had to pay more taxes, I think there should be more trees planted in the world.					
8. Even if it was more trouble for me, I would recycle things rather than just throw them away.					

	Probably not	Perhaps	Probably	Almost certainly	Deninitely
Statements	1	2	3	4	5
9. Even if it was more expensive, I would buy food grown without the use of artificial fertilizers.					
10. Even though it cost me money, I would get air conditioning in my home.					
11. Even if it was more trouble for me, I would not drop litter on the beach.					
12. Even if it meant that I didn't always have the latest 'gear' or fashion, I would be prepared to buy new things less often.					
13. Providing more of our energy was produced from the wind and waves and sun, I would be willing to pay more for electricity.					
14. Even if it took me longer and was more inconvenient, I would try to use buses and trains instead of a car.					
15. Even if I really liked meat, I would eat fewer meals with meat in them.					
16. Even if it cost me more, I would buy things for my home (like fridges and washing machines) that use less energy.					
17. I would vote for a politician who said they would bring in laws to reduce climate change, even though it would stop me doing some of the things I enjoy.					
18. I would vote for a politician who said they would increase taxes to pay for reducing climate change, even though it meant me having less money to spend.					
19. I would vote for a politician who said they would sign agreements with other countries on climate change, even though I might have to change the way I live.					
20. I would like to learn more about climate change, even though it would mean extra work for me.					

APPENDIX H

NEED FOR COGNITION SCALE

For each of the statements below, please indicate to what extent the statement is characteristic of you. Please rate according to the following scale:

1 = extremely uncharacteristic (EU); 2 = somewhat uncharacteristic; 3 = uncertain; 4 = somewhat characteristic; 5 = extremely characteristic (EC)

	extremely uncharacteristic	somewhat uncharacteristic	uncertain	somewhat characteristic	extremely characteristic
Statements	1	2	3	4	5
1. I would prefer complex to simple problems.					
2. I like to have the responsibility of handling a situation that requires a lot of thinking.					
3. Thinking is not my idea of fun.					
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.					
5. I try to anticipate and avoid situations where there is a likely chance I will have to think indepth about something.					
6. I find satisfaction in deliberating hard and for long hours.					
7. I only think as hard as I have to.					
8.I prefer to think about small, daily projects to longterm					

	extremely uncharacteristic	somewhat uncharacteristic	uncertain	somewhat characteristic	extremely characteristic
Statements	1	2	3	4	5
9. I like tasks that require little thought once I've learned them.					
10. The idea of relying on thought to make my way to the top appeals to me.					
11. I really enjoy a task that involves coming up with new solutions to problems.					
12. Learning new ways to think doesn't excite me very much.					
13. I prefer my life to be filled with puzzles that I must solve.					
14. The notion of thinking abstractly is appealing to me.					
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.					
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.					
17. It's enough for me that something gets the job done; I don't care how or why it works.					
18. I usually end up deliberating about issues even when they do not affect me personally.					

APPENDIX I

NEED FOR CLOSURE SCALE

Read each of the following statements and decide how much you agree with each according to your beliefs and experiences. Please respond according to the following scale:

1 = strongly disagree; 2 = moderately disagree; 3 = slightly disagree; 4 = slightly agree; 5 = moderately agree; 6 = strongly agree

	strongly disagree	moderately disagree	slightly disagree	slightly agree	moderately agree	strongly agree
Statements	1	2	3	4	5	6
1. I think that having clear rules and order at work is essential for success.						
2. Even after I've made up my mind about something, I am always eager to consider a different opinion.						
3. I don't like situations that are uncertain.						
4. I dislike questions which could be answered in many different ways.						
5. I like to have friends who are unpredictable.						
6. I find that a well ordered life with regular hours suits my temperament.						
7. When dining out, I like to go to places where I have been before so that I know what to expect.						
8. I feel uncomfortable when I don't understand the reason why an event occurred in my life.						
9. I feel irritated when one person disagrees with what everyone else in a group believes.						

	strongly disagree	moderately disagree	slightly disagree	slightly agree	moderately agree	strongly agree
Statements	1	2	3	4	5	6
10. I hate to change my plans at the last minute.						
11. I don't like to go into a situation without knowing what I can expect from it.						
12. When I have made a decision, I feel relieved.						
13. When I am confronted with a problem, I'm dying to reach a solution very quickly.						
14. When I am confused about an important issue, I feel very upset.						
15. I would quickly become impatient and irritated if I would not find a solution to a problem immediately.						
16. I would rather make a decision quickly than sleep over it.						
17. Even if I get a lot of time to make a decision, I still feel compelled to decide quickly.						
18. I think it is fun to change my plans at the last moment.						
19. I enjoy the uncertainty of going into a new situation without knowing what might happen.						
20. My personal space is usually messy and disorganized.						
21. In most social conflicts, I can easily see which side is right and which is wrong.						
22. I almost always feel hurried to reach a decision, even when there is no reason to do so.						
23. I believe that orderliness and organization are among the most important characteristics of a good student.						
24. When considering most conflict situations, I can usually see how both sides could be right.						

	strongly disagree	moderately disagree	slightly disagree	slightly agree	moderately agree	strongly agree
Statements	1	2	3	4	5	6
25. I don't like to be with people who are capable of unexpected actions.						
26. I prefer to socialize with familiar friends because I know what to expect from them.						
27. I think that I would learn best in a class that lacks clearly stated objectives and requirements.						
28. When thinking about a problem, I consider as many different opinions on the issue as possible.						
29. I like to know what people are thinking all the time.						
30. I dislike it when a person's statement could mean many different things.						
31. It's annoying to listen to someone who cannot seem to make up his or her mind.						
32. I find that establishing a consistent routine enables me to enjoy life more.						
33. I enjoy having a clear and structured mode of life.						
34. I prefer interacting with people whose opinions are very different from my own.						
35. I like to have a place for everything and everything in its place.						
36. I feel uncomfortable when someone's meaning or intention is unclear to me.						
37. I always see many possible solutions to problems I face.						
38. I'd rather know bad news than stay in a state of uncertainty.						
39. I do not usually consult many different opinions before forming my own view.						
40. I dislike unpredictable situations.						
41. I dislike the routine aspects of my work (studies).						

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