Res Sci Educ (2013) 43:2455–2475
DOI 10.1007/s11165-013-9368-8

Preservice Science Teachers' Efficacy Regarding a Socioscientific Issue: A Belief System Approach

Ahmet Kılınç · Tezcan Kartal · Barış Eroğlu · Ümit Demiral · Özlem Afacan · Dilber Polat · Mutlu P. Demirci Guler · Özkan Görgülü

Published online: 23 June 2013
© Springer Science+Business Media Dordrecht 2013

Abstract The aim of the present study was to understand the nature of teaching efficacy beliefs related to a socioscientific issue (SSI). We investigated Turkish preservice science teachers' teaching efficacy beliefs about genetically modified (GM) foods using a belief system approach. We assumed that preservice teachers' beliefs about GM foods (content knowledge, risk perceptions, moral beliefs, and religious beliefs) and their teaching efficacy beliefs about this topic constitute a belief system, and these beliefs are interrelated due to core educational beliefs. We used an exploratory mixed design to test this model. We developed and administered specific questionnaires to probe the belief system model. The sample for the quantitative part of this study included 441 preservice science teachers from eight universities. We randomly selected eight participants in this group for follow-up interviews. The results showed that preservice science teachers held moderately high teaching efficacy beliefs. Learning and teaching experiences, communication skills, vicarious experiences, emotional states, and interest in the topic were sources of this efficacy. In addition, content knowledge and risk perceptions were predictors of teaching efficacy. We believe that epistemologies based on traditional teaching and the values attached to science teaching are the core beliefs that affect the relationship between predictor variables and teaching efficacy.

Keywords Teaching efficacy beliefs · Socioscientific issues · Belief system · Preservice science teachers

A. Kılınç (✉)
Science Education Department, Abant İzzet Baysal University, 14280 Golkoy, Bolu, Turkey
e-mail: ahmet_tr@yahoo.com

T. Kartal · Ü. Demiral · Ö. Afacan · D. Polat · M. P. Demirci Guler · Ö. Görgülü
Ahi Evran University, Kırşehir, Turkey

B. Eroğlu
Aksaray University, Aksaray, Turkey

Introduction

Science interacts with technology and society (Lumpe et al. 1998). For instance, "many policy decisions have a science dimension. Decisions are made at various levels—from local to national—about waste disposal, energy policy, genetic engineering, emissions of CO_2, and so on. Such issues, which are broad social interest and involve a science dimension, are termed as SocioScientific Issues (SSI)" (Driver et al. 1996, p.18). Curriculum makers have started to incorporate these issues into the science curricula in different countries such as Australia, Turkey, UK, and USA because learning SSI contributes to the development of higher-order skills; improves beliefs about the nature of science, increases ethical and moral sensitivity; and promotes good citizenship (Fowler et al. 2009; Ratcliffe and Grace 2003).

Even though many countries incorporated SSI into their science curricula, these educational reforms presented many challenges for science teachers. Science teachers often believe that they do not have strong efficacy to use these issues in their teaching programs because of a range of factors, such as insufficient content and pedagogical knowledge, pressure from state examinations and families, and a lack of teaching materials (Day and Bryce 2010; Lee et al. 2006). Considering the fact that scholars (Sadler 2011; Zeidler and Nichols 2009) argue that science teachers need strong teaching efficacy to cope with these challenges when teaching about SSI, it is crucial to understand the nature and sources of teaching efficacy beliefs about SSI to identify better teacher training policies at both preservice and in-service levels. Consistent with this opinion, the purpose of the present study is to understand the nature of preservice science teachers' efficacy beliefs about teaching a socioscientific issue using a belief system approach.

Theoretical Framework

Belief Systems

Scholars (Abelson 1979; Nespor 1987; Pajares 1992; Rokeach 1968) agree that individuals possess belief systems that include all of their beliefs about the physical world, the social world, and the self. This system has a crucial function in enabling people to define and understand the world and themselves (Abelson 1979). Some scholars, such as Rokeach (1968) and Abelson (1979), have attempted to understand belief systems using psychological concepts. Rokeach (1968) suggests that a belief system includes a nucleus of core beliefs with other types of beliefs that surround this nucleus. He groups beliefs into five categories based on their connection to central beliefs and suggests that all people have these beliefs. Type A beliefs are "core beliefs" that are formed through personal experience. These beliefs are related to the nature of the self and are connected to societal norms. Thus, these beliefs are rarely changeable. Moving out from the core, other types of beliefs (B, C, D, and E) have different functions and different levels of immunity to change.

On the other hand, Abelson (1979) identified seven features that differentiate belief systems from knowledge systems: "evaluative and affective components", "episodic material", "unboundedness", "nonconsensuality", "existence beliefs", "alternative worlds", and "variable credences". The first three are particularly relevant for the present study. The "evaluative and affective components" of belief systems include both cognitive and motivational aspects. A belief system includes large categories of concepts that are defined as "good" or "bad". In addition to these subjective evaluations, feelings, physiological arousal, and moods are determinants of belief systems. Abelson (1979) says that belief systems also include "episodic material" from personal experience or from cultural and institutional sources of knowledge. These episodes may function as proof of a belief and may work as an illustration to enrich a concept. "Unboundedness" is another important feature of belief systems. Abelson (1979) suggests that it is unclear where to put a boundary around a belief system. Beliefs tend to be unbounded and they are readily expanded to phenomena that may be irrelevant to the context in which they were formed. He emphasized that belief systems always implicate the self-concept of the believer and self-concepts have wide boundaries.

Teachers' Efficacy Beliefs

Empirical and theoretical work has shown that teachers' beliefs exist as a system (Fives and Buehl 2012) and self-efficacy beliefs are an important component of this system (Pajares 1992). Bandura (1997) defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p.3). Teaching efficacy reflects "a teacher's belief that he or she can reach even difficult students and help them learn" (Woolfolk 2001, p.389). Fives (2003) suggests that teaching efficacy as a belief is expected to guide teachers in their behaviors, motivation, and decisions about teaching.

Bandura (1997) argued that efficacy beliefs had four sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological arousal. He noted that the most effective way to develop a strong sense of self-efficacy is through mastery experiences: They provide the most authentic evidence of whether one can master whatever it takes to succeed. Teaching a class, having field experience or tutoring a child are examples of teachers' mastery experiences (Fives 2003). Vicarious experiences are gained by observing others. Observing the achievements of people who are similar to oneself increases observers' beliefs that they can achieve similar tasks. For example, preservice teachers usually observe effective lecturers in content and pedagogy courses and feel that they could teach well (Ertmer 2005). The third source of efficacy beliefs is verbal persuasion. People who are persuaded verbally that they possess the capabilities to master activities are likely to exert and sustain greater effort than those who harbor self-doubts and dwell on personal deficiencies when problems arise (Bandura 1997). Feedback from students, students' parents, colleagues, and teacher educators (for preservice teachers) function to persuade teachers to either persist in teaching activities or give up (Fives 2003). The last source is physiological arousal. Stress reactions and tension are interpreted as signs of poor performance, whereas a positive mood enhances perceived efficacy (Bandura 1997). Examples of these reactions include "anxiety" related to courses for which a teacher does not have an educational background and "happiness" related to teaching a subject to low-achieving students.

A Belief System Model for Understanding Teaching Efficacy Beliefs About a Socioscientific Issue

We developed and tested a belief system that we assumed was maintained by preservice science teachers in the present study. Figure 1 presents this system. Beliefs about content and beliefs about the pedagogy of content are the two main groups of belief in this system. A review of the existing literature suggests that preservice teachers and teachers' beliefs about educational content influence their beliefs about the pedagogy of this content (Kagan 1992). Teachers' religious beliefs about evolution, for example, affect their intention to include evolution in science teaching (Nehm et al. 2009). Similarly, teachers' epistemological beliefs about science affect their orientation toward teaching science (Tsai 2002). The existing

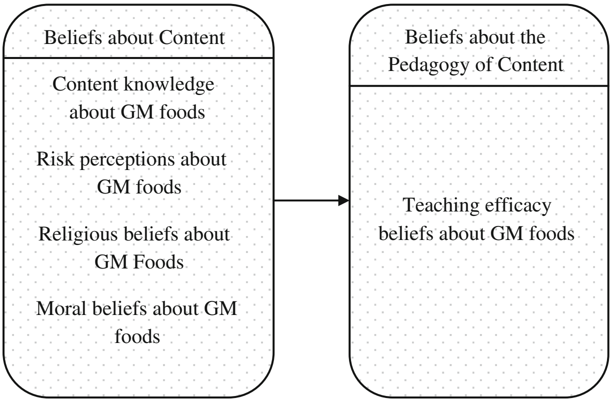

Fig. 1 Theoretically assumed belief system for teaching about GM foods

literature on teachers' beliefs contains many such examples. We believe that the "unbounded" nature of belief systems (Abelson 1979) is responsible for the relationship between beliefs about content and beliefs about the pedagogy of content. In other words, teachers extend their personal beliefs about content (personal identity) to their beliefs about the pedagogy of this content (professional identity).

For the content, we selected genetically modified (GM) foods as a socioscientific issue. GM foods include both social and technological aspects, and controversies exist among scientists and the public about the development and support of these foods (Gaskell et al. 2004). In the case of teaching about GM foods, we suggest that preservice teachers' "personal" beliefs about GM foods will affect their "professional" beliefs about teaching this topic. Because we sought to understand the nature of teaching efficacy beliefs and their sources, we selected different beliefs, such as "content knowledge", "risk perceptions", "religious beliefs", and "moral beliefs" that had the theoretical potential to affect efficacy beliefs in the case of GM foods.

Although content knowledge about GM foods could be included in knowledge systems, it is one dimension of beliefs about content in our model. As Rokeach (1968), Abelson (1979), and Kagan (1992) suggested, we accept content knowledge as a belief that can be incorporated in a belief system. The literature shows that content knowledge is a crucial aspect of teaching efficacy beliefs and that as content knowledge increases, teachers' confidence levels also increase (e.g., Palmer 2006). In accordance with the existing literature, we expect that as teachers' content knowledge about GM foods increases, their teaching efficacy beliefs about this topic will also increase. We assumed that many preservice teachers in the Turkish sample would believe that "knowledge" was something to be transferred from teachers to students (Yılmaz-Tüzün and Topçu 2008), perhaps because of their "episodically stored" (Abelson 1979) experiences as school students and preservice teachers.

Risk perceptions about GM foods were another dimension of beliefs about GM foods. As emphasized by Kılınç et al. (2013) and Christensen (2009), we believe that risk perceptions are crucial to understanding SSI. Risk perceptions by individuals include informal estimations of the probability of an event occurring combined with an evaluation of the individual's level of concern about the negative consequences of such an incident (Sjöberg et al. 2004). We suggest that teachers' beliefs about the risks of GM foods' (risk perceptions) affect their teaching efficacy beliefs about this topic. We assume that as risk perceptions about GM foods increase, teaching efficacy beliefs about this topic will become stronger. This assumption was also confirmed by three risk psychology professors and two teacher motivation researchers. The rationale for this assumption is a combination of "core beliefs" (Rokeach 1968) and the "evaluative and affective components" of belief systems (Abelson 1979). We suggest that the riskier a student teacher finds the concept of GM foods, the more willing he/she would be to teach about this topic and to cope with the challenges in teaching because of the risk mitigation potential for students. This process is likely to stem from a "core belief", such as a desire to promote social justice and informed decision making among students (Cross and Price 1996).

Religious beliefs about GM foods are another dimension in our model. Muslims constitute the largest portion of the Turkish population (98 %), although there are various religions in the country (Pew Research Center 2011). Unlike some other Muslim countries, Turkey has a secular democracy in which religious and governmental affairs function independently. In an Egyptian sample, Mansour (2008) found that teachers' understandings and interpretations of Islamic religious beliefs filtered their interpretations of science and Science-Technology-Society instruction. Although Turkey differs from Egypt in terms of the possible influence of religious beliefs on teaching practices, we examined whether preservice teachers' religious beliefs would affect their reactions to teaching about GM foods. We expected that preservice teachers who approached the topic of GM foods from a religious perspective would have reduced teaching efficacy beliefs about this topic. The rationale for this assumption was our expectation that preservice teachers with religious beliefs would not include these topics in their teaching programs and therefore would not develop strong teaching efficacy beliefs.

The last dimension in the group of beliefs about GM foods is moral beliefs. Moral beliefs are one of the most commonly studied areas in the SSI-based education literature (e.g., Fowler et al. 2009). We assumed that when a preservice teacher found GM foods morally wrong, their teaching efficacy related to this topic would increase. We suggest that teachers who believe that genetic modification sits in opposition to their principles and emotions, will develop "core beliefs" as well as "affective and evaluative components" in relation to risk perceptions and teaching efficacy beliefs. In other words, teachers with moral beliefs about GM foods would want to teach these topics (Bryce and Gray 2004) and master teaching them so that their students could make informed decisions and approach GM foods from a moral perspective.

Purpose and Research Questions

The purpose of this research was to investigate Turkish preservice science teachers' teaching efficacy beliefs about GM foods using a belief system approach. We attempted to answer the following research questions:

1. What is the nature of preservice science teachers' teaching efficacy beliefs about GM foods?
2. To what degree does the belief system model (Fig. 1) reveal the contributions of factors related to teaching efficacy beliefs about GM foods?

Methods

This study adopted an explanatory mixed methods design (Cresswell 2008). This design consists of collecting quantitative data (first stage) and then collecting qualitative data (second stage) to explain and elaborate quantitative consequences (Creswell 2008). We first administered questionnaires to preservice science teachers and investigated their responses using quantitative analyses, including factor analysis and structural equation modeling

(Tabachnick and Fidell 1996). In accordance with the results of these analyses, we conducted follow-up interviews with a randomly selected small sample to better understand the underlying reasons for the results we identified in the first stage.

Quantitative Research

Sample

We selected preservice science teachers as the sample in the present study using convenience sampling procedures. Eight Turkish universities with Teaching Science departments in different regions of Turkey were selected. Our sample included 441 (164 [37.3 %] male, 277 [62.7 %] female) preservice science teachers with a mean age of 21.8 (SD=1.29, range=19–28). In addition, we purposefully selected years 3 and 4 participants because these students had taken many pedagogical and science courses. In this sample, 237 (53.7 %) participants were in year 3 and 204 participants (46.3 %) were in year 4.

Development of Teacher Belief System Questionnaire

A Teacher Belief System Questionnaire (TBSQ) was developed by the authors using the belief system model in Fig. 1. The TBSQ included five subquestionnaires: content knowledge about GM foods (CKGF), moral beliefs about GM foods (MBGF), religious beliefs about GM foods (RBGF), risk perceptions about GM foods (RPGF), and teaching efficacy beliefs about GM foods (TEBGF). The questionnaire was preceded by a cover sheet requesting personal information, such as gender, age, university, and year group. The TBSQ is included as "Appendix". The selection of the items was made based on questionnaires that are frequently used in the literature (please see Table 1). In the development of TEBGF, we also conducted semistructured interviews with six experienced science teachers regarding their teaching efficacy beliefs about SSI. In these interviews, teachers' understandings of SSI, actual teaching experiences, confidence in teaching these topics, and the sources of their teaching efficacy were examined.

After the selection of items, a meeting was held with 16 participants. This group included four science education professors, a professor who worked in genetics and biotechnology, a professor who was an expert in statistics and the development of questionnaires, a reading education professor, a lecturer from the Turkish Language and Literature department, three doctoral students, and six master's students. This group scrutinized the items and the layout of the subquestionnaires in terms of content and language. Minor changes were made to some items.

After pilot tests with large samples, final versions of CKGF included 8 items, MBGF included 5 items, RBGF included 5 items, RBGF included 13 items, and TEBGF included 16 items. In addition, factor analyses with maximum likelihood and oblique rotation that were applied to TEBGF yielded four factoral structures: efficacy beliefs about general instructional strategies, efficacy beliefs about the nature of science (NOS), efficacy beliefs about incorporating families, and efficacy beliefs about explanations. The alpha reliability scores of subquestionnaires and subdimensions of TEBGF ranged from 0.53 to 0.94.

Administration of the Teacher Belief System Questionnaire

All of the lecturers at the universities in the sample distributed the questionnaires in their regular classrooms and allowed time for the clarification of participants' queries. The participants completed the questionnaires in approximately 20 min.

Table 1 The item resources and response alternatives of subquestionnaires

Subquestionnaire	Abbreviation	Available responses	Item sources
Content knowledge about GM foods	CKGF	True False Do not know	Eurobarometer (2010); Sjöberg (2008)
Risk perceptions about GM foods	RPGF	Absolutely not Very little Rather little To some extent To a rather high degree To a high degree To a very high degree	Fischhoff et al. (1978); Sjöberg (2008)
Moral beliefs about GM foods	MBGF	I completely disagree I disagree I neither agree nor disagree I agree I completely agree	Eurobarometer (2010)
Religious beliefs about GM foods	RBGF	I completely disagree I disagree I neither agree nor disagree I agree I completely agree	Eurobarometer (2010)
Teaching efficacy beliefs about GM foods	TEBGF	Nothing (1).... A great deal (9)	Riggs and Enochs (1990) Semistructured interviews

Data Analysis

We used various descriptive and inferential analyses in the present study. Frequencies, percentages, mean scores, and standard deviations were used as descriptive statistics to understand the psychometric factors of GM foods. Structural equation modeling (SEM) was used as an inferential analysis to test the belief system presented in Fig. 1 and to determine the predictors of teaching efficacy beliefs related to GM foods.

Qualitative Research

Upon finalizing the quantitative research, we conducted follow-up interviews with a randomly selected small sample (eight participants) to better understand the underlying reasons for the results we obtained in the first stage. A random sampling strategy was adopted since the standard deviation scores were not too high for each parameter. Five male and three female participants were randomly selected.

Interview Procedure

The author conducted all of the semistructured interviews. The author first used personal information (names, telephone numbers, and e-mail addresses) from the coversheets of the questionnaires and arranged appointments with the participants to conduct the interviews. Audiorecording equipment was used during the interviews. Each interview lasted approximately 45 min. The semistructured interview procedure that was used by the author was as follows:

Stage 1 Explain the research purposes and why the researchers wanted to conduct follow-up interviews with the participants.
Stage 2 Explain how the participants were selected and ask permission to conduct the interview.
Stage 3
- (a) Read the scores of the participant for CKGF with the mean, standard deviation, and range scores for all participants so that participant can understand where he/she stands among all of the participants.
- (b) Read knowledge items one by one and give the participant's score for each item.
- (c) Ask why the participant received those knowledge scores and attempt to get detailed information through further questions.

Stage 4 Repeat the process in stage 3 for all of the other parameters (risk perceptions, religious beliefs, moral beliefs, and teaching efficacy beliefs) one by one.
Stage 5 Ask the following questions and encourage the participants to explain their answers as much as possible.

- (a) Do you think that there is a relationship between preservice teachers' content knowledge about GM foods and their teaching efficacy beliefs about this topic? Can you explain your answer further?
- (b) Do you think that there is a relationship between preservice teachers' risk perceptions about GM foods and their teaching efficacy beliefs about this topic? Can you explain your answer further?

Data Analysis

First, the audiorecordings were transcribed to Excel pages. The transcripts were printed for subsequent content analysis. The two authors independently conducted content analysis on the transcripts. They both adopted Creswell's (2008) content analysis approach that was used in previous research (for further information about content analysis; please see Kılınç et al. in press). The authors read the transcripts and identified overlapping themes in the responses. Because the fundamental goal was to understand the main sources of the beliefs, the thematic analysis focused on the reasons that participants offered for their scores on the questionnaires. Upon finalizing this thematic analysis, the inter-rater reliability coefficients were calculated. The scores were 0.97 for responses about content knowledge, 0.96 for risk perceptions, 0.92 for moral beliefs, 0.96 for religious beliefs, and 0.88 for teaching efficacy beliefs. The authors then came together and discussed the themes until 100 % agreement was reached.

Results and Discussion

In this section, our goal is to combine quantitative and qualitative results for each parameter and to discuss them using our theoretical assumptions as well as the related literature.

Beliefs About GM Foods (Beliefs About Content)

Content Knowledge About GM Foods

All of the items were correctly answered by more than 60 % of the participants in the quantitative research. Most of the participants were aware of fundamental genetic implementations, the areas in which genetic modification was used and genetic engineering methods. We can conclude that the participants were relatively well informed about GM foods.

About this relatively strong knowledge background, we found that three main knowledge sources emerged in the transcripts in qualitative research. These are undergraduate courses, informal environment, and interest in food technologies. The importance of undergraduate courses such as “Genetics and Biotechnology” and “Specific Issues in Biology” were emphasized by all of the interview participants. Considering the content of these courses, Genetics and Biotechnology covers the concepts of genes, chromosomes and heritage, molecular biology, human genetics and genetic illnesses, genetic engineering, and its effects on society and basic rules of biotechnology. The course of Specific Issues in Biology is related to recent developments in biology: the importance of biology for society, GM organisms, stem cell technology, cloning, nanobiology, and so on. We believe that preservice teachers have many opportunities to learn about GM foods in these courses. In addition to these formal sources, preservice science teachers may bring many informal experiences (newspapers, the internet, and peer discussions) to university classrooms, and this combination of informal and formal experiences enriches their knowledge background.

Risk Perceptions About GM Foods

The quantitative results show that the participants found GM foods risky and chose the response alternatives “To some extent (4)” and “To a high degree (5)”. They believed that GM foods present a high risk to human health. Cancer (M=4.98, SD=1.03), illnesses in future generations (M=4.92, SD=0.96), and harmful effects on humans (M=4.71, SD=0.93) were the risks that had high mean scores. Most of the participants considered GM foods severe (M=4.81, SD=0.98) and unknown (M=4.70, SD=0.90), but they did not consider them rather dreaded (M=4.37, SD=1.13).

Looking at the transcripts, concerns about biodiversity loss, uncertainty about the future effects of GM foods on human health and knowledge about the risks and benefits seem to be sources of the interview participants’ risk perceptions of GM foods. Regarding the first source, three interviewees believed that GM technology would create species that have the same (demanded) characteristics, such as an attractive appearance and good taste. Therefore, these species would not survive when an extreme event occurred. Regarding the second source, two interviewees expected future health problems among humans. One of these interviewees was skeptical about GM technology because there was a chance that negative effects would accumulate in the body. The other source of risk perceptions was knowledge about the risks and benefits of GM foods. Two interviewees said that as one’s knowledge about GM foods increases, his/her risk perceptions about these foods also increase.

Taken together, in the case of risk perceptions of GM foods, preservice teachers found GM foods risky, especially in terms of their possible effects on human health and biodiversity. According to the psychological paradigm (Fischhoff et al. 1978), which is a theory that is frequently used to understand risk perceptions (Kılınç et al. 2013), “dread” and “unknown” characteristics are the main sources of risk perceptions. Concurrent with this line of reasoning, the preservice teachers in the present study considered GM foods severe and unknown. In terms of severity, they said that these foods could cause illnesses, such as cancer, in current and future generations, and they worried about biodiversity loss. Regarding the “unknown” characteristics of risk perceptions, some interviewees believed that there were uncertainties about the future effects of this technology. They said that the harmful effects of GM technology would emerge in the next generations, and these effects had the potential to accumulate in the human body.

For clarity, we gave the percentages that represent the combination of “I completely agree” and “I agree” answers in the comments regarding moral beliefs and religious beliefs.

Moral Beliefs About GM Foods

The quantitative results showed that only about one quarter of the participants (21 %) stressed that they did not eat GM foods due to moral reasons. In terms of emotional aspects, a small proportion of the participants reported that they would feel embarrassed (25 %), whereas about one half (44 %) said they would feel guilty if they preferred GM foods over other foods. Over one half (58 %) of the participants said that buying GM foods would conflict with their principles. However, approximately one third (32 %) said that they did not have any moral problem with GM foods.

Looking at the transcripts, three interviewees offered infrastructural reasons about their weak moral beliefs in the case of GM foods. They said that the moral aspect was not a criterion when buying these foods because they had to buy them due to the unavailability of labeling systems in Turkey. However, a few interviewees agreed that buying GM foods conflicted with their principles and emotions. The interviewees stressed that these foods would cause health problems, such as cancer and genetic mutations, in the current human population and in future generations.

Considering both quantitative and qualitative results, although we expected preservice science teachers to possess strong moral beliefs about GM foods, the results differed from our expectations. Approximately one in five (21 %) of the participants said that they did not eat GM foods due to moral reasons. Although a few interviewees suggested that concerns about human health were a main source of moral beliefs, some interviewees believed that moral aspects were not important when buying these foods because they had to purchase them due to the lack of labeling systems in Turkey. In the Turkish context, GM foods cannot be sold in markets, except for a few GM plant species, such as soybeans and corn, which are used as animal feed (Turkish Biosafety Council 2012). However, some NGOs, consumer organizations, and scientists believe that Turkish people already consume GM foods that have been imported illegally (Hurriyet Daily News 2012). Perhaps because awareness has been raised by the media, many people in Turkey believe that they already consume GM foods without a labeling system. We believe that the lack of a labeling system and the idea that people already buy these foods have prevented the development of strong moral beliefs among preservice teachers because there seems to be no clear alternative.

Religious Beliefs About GM Foods

The quantitative results showed that only about one fifth (21 %) of the participants agreed that the genetic modification of organisms interfered with God’s work. A similar proportion (19 %) said that genetic modification was a sin. A small percentage of the participants believed that people who made genetic modifications would be punished by God during their lifetime (10 %) or after their death (13 %). Only 4 % thought that eating GM foods was a sin. We can conclude that the participants did not adopt a religious perspective in their evaluations of GM Foods. They commonly used the “Neither agree nor disagree” response.

In qualitative research, six out of eight interviewees said that religion and science were different dimensions and should not be confused. A few interviewees in this group said that religious beliefs should be separated from science. Another noted that religion had the potential to distance people from reality. On the other hand, two interviewees believed that there would be no problem in terms of religious aspects because this technology was beneficial. They said that their religion (Islam) supported activities that were in favor of humans. Two other interviewees chose the “neither agree nor disagree” response for all items. They said that they did not have information about the relationship between Islam and genetic modification.

Overall, preservice teachers did not find GM foods problematic in terms of religious aspects. Most of the interviewees said that science and religion were different perspectives and should not be confused. This was an expected result because Turkey is a Muslim country with a secular democracy. Unlike some other Muslim countries, such as Egypt (for further information, please see Mansour 2008), religious beliefs do not exert a significant influence on teaching practices in math, science, and other courses in state schools. Religious education is offered by state schools at the primary and secondary levels; however, students learn positive sciences without the influence of religion.

Teaching Efficacy Beliefs Regarding GM Foods (Beliefs About Pedagogy of Content)

The Structure of Efficacy Beliefs

According to descriptive results about TEBGF, the participants had moderately high teaching efficacy beliefs regarding GM foods. Considering the factorial structures, the highest mean score was for teaching efficacy beliefs about general instructional strategies (M=6.52, SD=1.04, range=1–9) followed by beliefs about explanations (M=6.49, SD=1.23, range=1–9), beliefs about NOS (M=6.30, SD=1.18, range=1–9) and beliefs about incorporating families (M=6.27, SD=1.22, range=1–9). Table 2 displays the descriptive results for each efficacy item.

As can be seen, the descriptive results showed that Turkish preservice teachers possessed moderately high teaching efficacy beliefs about GM foods. Considering the many problems in-service teachers experience when teaching SSI, this result is crucial for the development of teaching programs in similar contexts or in other settings. However, we need to be careful about this result since their mastery experiences, which are the most effective source of self-efficacy, in the case of teaching SSI, are very limited in current Turkish science teacher education. Consistent with this caution, their confidence level in using “general instructional strategies”, such as course planning, assessment, applications of teaching methods, management of discussions, keeping students’ attention, and “‘making explanations” to students’ queries, was higher than the confidence level for those teaching NOS and incorporating families into the learning process that are specific components of teaching SSI. Preservice teachers may “episodically” remember their teaching practices for other subjects in the science curriculum in the Science Teaching Methods course or in state schools. They are likely to move along a continuum of beliefs about teaching other science topics and teaching GM foods based on the unbounded nature of belief systems. Therefore, we believe that preservice teachers do not identify significant differences between teaching noncontroversial topics and socioscientific issues in terms of explaining and applying general instructional strategies.

Table 2 The efficacy items and their means, standard deviations, and ranges

Factor	Item	*M*	SD	*R*
Teaching efficacy beliefs about GIS	GIS1, How well can you determine learning goals for this course?	6.75	1.38	1–9
	GIS2, How well can you assess whether students grasped the knowledge and concepts taught in this course?	6.41	1.36	1–9
	GIS3, How much can you do to get students to believe they can make informed decisions in their future?	6.47	1.35	2–9
	GIS4, How much can you do to keep students' attention during discussions?	6.54	1.31	1–9
	GIS5, How well can you use different teaching methods in teaching controversial issues, such as GM foods?	6.43	1.49	2–9
	GIS6, How much can you do to adjust the concepts and discussions about GM foods to the proper level for individual students?	6.40	1.33	1–9
	GIS7, How much can you do to motivate students who show low interest in the subject so they join the discussions?	6.65	1.37	1–9
Teaching efficacy beliefs about FAM	FAM1, How well can you teach decision-making skills in schools in rural places?	6.31	1.48	1–9
	FAM2, How well can you specify the need for teaching controversial issues to families?	6.39	1.40	2–9
	FAM3, How well can you incorporate families in teaching decision-making skills about these issues?	6.10	1.48	1–9
Teaching efficacy beliefs about NOS	NOS1, How well can you get your students to understand the fact that values and beliefs are important in explaining these issues?	6.02	1.54	1–9
	NOS2, How well can you teach how scientific knowledge is produced about GM foods?	6.41	1.47	1–9
	NOS3, How well can you get your students to learn the nature of aspects of the news about GM foods in the media?	6.48	1.32	2–9
Teaching efficacy beliefs about EXP	EXP1, How well can you explain the scientific experiments about GM foods?	6.41	1.50	1–9
	EXP2, How well can you respond to questions about GM foods to be raised by students?	6.52	1.43	1–9
	EXP3, To what extent can you provide an alternative explanation or example when students are confused?	6.54	1.47	3–9

When it comes to teaching NOS and incorporating families into the teaching process, their teaching efficacy decreases. This result is in line with the existing literature (Kılınç et al. 2013; Lee et al. 2006). About teaching NOS, we believe that Turkish preservice science teachers are likely to have naive beliefs about NOS (Dogan and Abd-El-Khalick 2008) and do not have the opportunity to explicitly or implicitly embed NOS into science instruction in the Turkish context. Therefore, they do not have a strong knowledge base or skill in teaching about the interrelations between social, cultural, and personal issues in the development of scientific knowledge and its communication. In addition, many teachers have concerns about parents' reactions to SSI education (McGinnis and Simmons 1999). Preservice teachers in the present study did not have strong efficacy to incorporate parents into the teaching decision-making process. Their teaching efficacy level was low for students in rural areas, perhaps because they believed that parents in these areas possessed strong religious and moral beliefs against controversial issues such as genetic modification (McGinnis and Simmons 1999).

The Sources of Efficacy Beliefs

About the sources of these moderately high efficacy scores, the interviewees emphasized six main factors in the transcripts: learning experiences, teaching experiences, communication skills, interest in GM, emotional states, and vicarious experiences. Considering the fact that experiences of learning, teaching, and communication skills can be mastery experiences, these six factors are in line with the suggestions of Bandura (1997) for the sources of efficacy beliefs.

Regarding learning experiences, all of the interviewees believed that if a teacher has sufficient knowledge about the content of a topic, he/she could teach that topic well. They believed that good learning experiences in undergraduate science courses such as Specific Issues in Biology were crucial to explain controversial issues about GM foods. About teaching experiences, four interviewees described teaching practices that included microteaching activities in the Science Teaching Methods (STM) course, teaching sessions in state schools, tutoring experiences, and teaching in part-time test centers. The STM course is offered in two academic semesters. STM1, which is a more theoretical course than STM 2, covers topics such as the fundamentals of science teaching, scientific literacy, constructivism, and conceptual change. In STM2, microteaching activities are conducted. In addition, the teaching practicum in the Science Teacher Education program in Turkey covers two applied courses, School Experience and Teaching Practice, which are conducted in state schools. In the School Experience course, preservice teachers are sent to state schools to observe students, teachers, and the school community. In the Teaching Practice course, preservice teachers plan their own teaching sessions and conduct these sessions in real classrooms. Similar to the teaching practicum in state schools, some preservice teachers experience teaching as science teacher assistants or science teachers in part-time private test centers. These centers prepare students for the Exam for Accessing Highschools (EAH) by developing their test skills and knowledge background. Tutoring is another teaching experience for preservice teachers. A few interviewees said that they taught genetic modification to their students and/or relatives so that they would pass examinations or the EAH. Even if only a few of the student teachers we interviewed discussed GM foods in their teaching practices in state schools, private test centers, or tutoring, we believe that they episodically remember their teaching sessions about other science topics and transfer their beliefs about these sessions to their beliefs about teaching GM foods.

Three interviewees said that personal communication skills, such as speaking, storytelling, and discussion were crucial factors in the development of efficacy beliefs. They believed that communication skills were a criterion for becoming a good teacher. This situation is also emphasized by many teachers (Kılınç et al. 2012). However, in the case of teaching SSI, this criterion is crucial. Two interviewees believed that interest in a topic was an important dimension of teaching that topic. One of these interviewees said that she was interested in food and food technologies and that teaching these topics would not be difficult due to her interests. We believe that this interest motivates individuals to improve their mastery of learning and teaching biology and/or food technology.

Emotional states were another important source of teaching efficacy beliefs. Two interviewees who had lower efficacy relative to others said that they would feel anxiety when teaching these topics. They said that these issues were controversial and that they did not know what to teach. They also believed that their beliefs, values, and religious perspectives came into play in these issues. Although they did not have these negative feelings in real classroom conditions, we believe that these feelings might hinder the future practices of some preservice teachers. Regarding vicarious experiences, two interviewees said that they were similar to the lecturers in the Specific Issues in Biology and Science Teaching Methods courses in terms of their teaching style. Accordingly, we can say that the content and pedagogy of content courses in teacher training also function as environments in which preservice teachers experience teaching vicariously. In addition, because many of the preservice teachers did not teach GM foods in real classroom conditions, they were likely to consult their episodically stored memories regarding how their lecturers in other courses behaved.

Belief System for Teaching About GM Foods

According to the belief system model in Fig. 1, we assumed that beliefs about GM foods (content knowledge, moral beliefs, religious beliefs, and risk perceptions) would predict beliefs about the pedagogy of GM foods (teaching efficacy beliefs). Our theoretical structural model based on this belief system is displayed in Fig. 2. Because the proposed structural relationships between parameters can be conducted through SEM analysis, all participants' responses in quantitative research were analyzed using AMOS 18. The theoretical model was evaluated and compared with the various fit measures. Confirmatory testing of the theoretical model revealed that the model could be accepted from an empirical point of view. Considering the fit indices (chi-square=1,623,356, chi-square per degree of freedom=1,836, RMSEA=0.044, GFI=0.85, NFI=0.85, TLI=0.92, and CFI=0.93), we can say that theoretical structure has a strong model fit (Tabachnick and Fidell 1996).

Figure 2 also shows the summary of the maximum likelihood parameter estimates (standard coefficients) and the significance of the *t* values as indicated by asterisks. Knowledge (content knowledge about GM foods) and risk (risk perceptions about GM

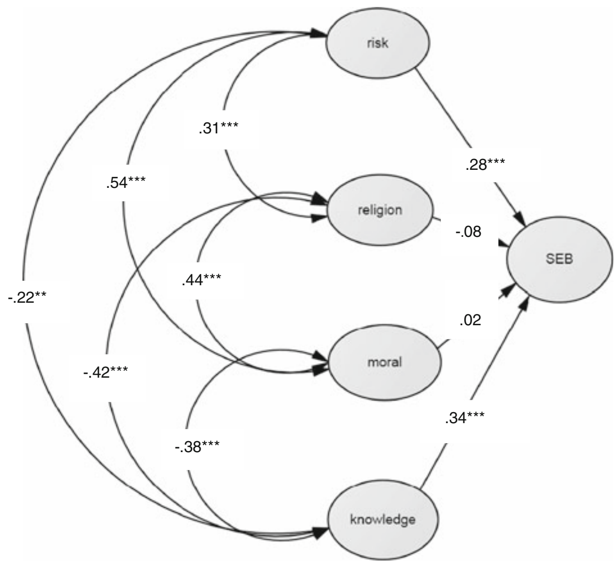

Fig. 2 Theoretical structural model based on the belief system in Fig. 1 and maximum likelihood parameter estimates (**$p<0.01$, ***$p<0.001$). *Risk* risk perceptions about GM foods, *religion* religious beliefs about GM foods, *moral* moral beliefs about GM foods, *knowledge* content knowledge about GM foods, *TEB* teaching efficacy beliefs about GM foods

foods) were significant predictors of the variation in TEBGF. Religious beliefs (beta=−0.08) and moral beliefs (beta=0.02) had small and nonsignificant relations with teaching efficacy beliefs. In addition, the independent variables were significantly correlated with one another between −0.42 and 0.54.

In addition to these quantitative results, we asked the interviewees questions about the relationship between significant predictors and teaching efficacy beliefs in our structural model in Fig. 2 (stage 5). About the first predictor, we asked what the interviewees thought about the relationship between content knowledge and teaching efficacy beliefs. All of the interviewees said that as a teacher's content knowledge about GM foods increased, his/her teaching efficacy about GM foods also increased. Four interviewees said that content knowledge enhanced their self-confidence in teaching. Three interviewees considered knowledge material to be conveyed from the teacher to the students and believed that teaching methods or environments were tools to achieve this goal. Therefore, they suggested that a lack of knowledge implied a lack of teaching and learning. The following excerpt reflects this reasoning:

> Actually, you can convey a thing that you know very well. How can you convey a thing about which you do not have knowledge (participant 3)?

Two other interviewees believed that content knowledge was crucial to answer students' questions, especially for controversial topics. In addition, one participant said that teachers should have considerable content knowledge about these topics because there were many different findings, results, and viewpoints. Another participant believed that knowledge about GM foods encouraged teachers to teach these topics to students who would need to make decisions about GM foods in the future.

With respect to the second predictor, we asked the interviewees how they understood the relationship between risk perceptions and teaching efficacy beliefs. Six interviewees said that the topics that teachers found risky triggered them to teach these topics effectively. Three interviewees in this group said that they wanted to direct children, who were the future of the country, toward organic foods and prevent them from being exposed to the harmful effects of GM foods. The following excerpt reflects this reasoning:

> I should incorporate these topics into my teaching program and teach it well. In the end, we are teachers and educate humans. I am only one person, but I have 30 students. When they become adults, they should be aware of these topics and take precautions accordingly (participant 4).

One of these interviewees said that he felt responsibility toward children. Similarly, two interviewees stated that they wanted to make children think critically and consider what would happen in the future by clearly explaining the realities of GM foods. One interviewee said that a teacher who found these topics risky would teach them easily because he/she would make strong connections between the topic and his/her personal life. Another interviewee said that teachers with high efficacy beliefs would take risks, such as teaching risky topics, and would design these courses better than other courses, such as courses on photosynthesis. In contrast to these comments, one interviewee challenged this line of reasoning; he believed that if he found a topic risky, he would experience fear and could not teach it well.

Taken together, as we show in Fig. 3, we suggest that core beliefs (Rokeach 1968), such as epistemologies about learning and teaching and the values attached to science teaching, affect the "peripheral beliefs" about content, and the pedagogy of content. The unbounded nature of belief systems (Abelson 1979) facilitates the transfer from one belief cluster to

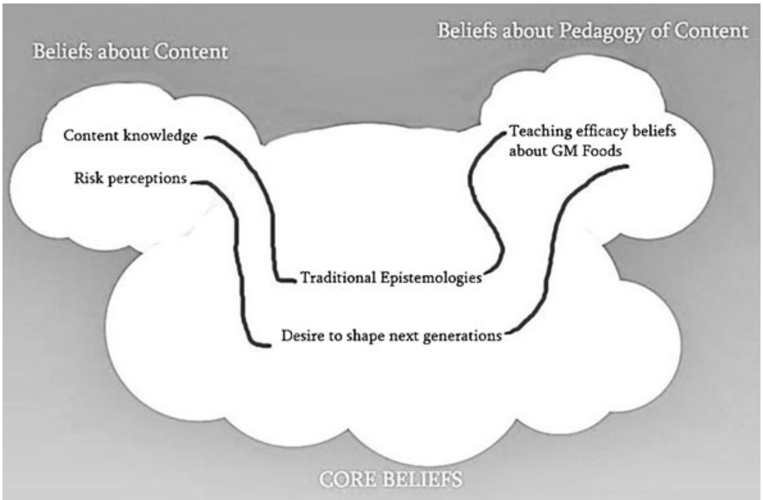

Fig. 3 Final version of belief system informed by the results of the present study. We used "*lines*" to show the relationships between different beliefs since we consider that the relationships between the parameters are bidirectional. Desire to shape next generations, for example, may enhance risk perceptions about GM foods and teaching efficacy beliefs about same topic, whereas risk perceptions and teaching efficacy beliefs (and teaching practices) may make the desire to shape next generations stronger. In addition, there may be direct relationships between content beliefs and pedagogy of content beliefs, but we consider that core beliefs are potentially work as a filter (Fives and Buehl 2012) between peripheral beliefs

another. In the case of the relationship between content knowledge and teaching efficacy beliefs, all of the preservice teachers confirmed that as a teacher's content knowledge increased, his/her self-confidence in teaching that content also increased. Along with our assumptions, preservice teachers' core beliefs about teaching based on knowledge transfer led them to think of knowledge as material to be transferred from the teacher to the students. This core teacher belief is frequently observed in many other contexts such as USA (Bryan 2003) and Taiwan (Tsai 2002). Although Turkish preservice teachers are educated using constructivist perspectives in undergraduate pedagogy courses, the teaching activities in undergraduate science courses and, more importantly, their experiences as students in middle and secondary school are likely to be the main sources of their traditional core beliefs about science instruction.

The result about the relationship between risk perceptions and teaching efficacy beliefs is also in line with our assumption. Most of the interviewees said that their risk perceptions encouraged them to teach these topics effectively so that children, who were future citizens, would take precautions and make informed decisions about GM foods. As stated previously, we believe that preservice teachers possess core educational beliefs based on task values (affective components of belief systems), such as a desire to shape future generations, and these beliefs explain the relationship between risk perceptions and teaching efficacy beliefs. We are aware that social utility values are very important motivators for preservice teachers in Turkey because of the collective cultural structure (Kılınç et al. 2012). However, even in individualistic cultures, we see a similar tendency to teach about SSI because teachers feel responsible for children and future generations (Cross and Price 1996). Therefore, there may be a general predisposition to teach about these issues due to the value of science teaching and the social goals of science instruction.

Implications for Science Teacher Education

For effective SSI-based education in real classrooms, we believe that some undergraduate science and pedagogy courses are essential for science teacher education programs. SSI are current and highly controversial topics. Therefore, it is necessary for preservice teachers to develop strong content (subject matter) knowledge (Day and Bryce 2010; Sadler 2011) via undergraduate “science courses”, such as Specific Issues in Biology and Genetics and Biotechnology, because content knowledge is a positive and significant predictor of teaching efficacy. Furthermore, these courses provide environments in which teachers can have vicarious teaching experiences. They may also increase preservice teachers’ interest in these issues, which is another source of teaching efficacy. Obligatory and/or elective science courses that include recent developments in SSI, such as cloning, gene therapy, and nuclear energy, with rich content and effective learning materials are suggested. In addition to the development of knowledge background, these “science courses” should also include the discussions about nature and social aspects of SSI science, ideologies, religious beliefs, moral beliefs, and risk perceptions of the public since these content-specific beliefs may be influential in the development of efficacy beliefs about teaching SSI.

About pedagogy courses, it is important to incorporate Science Teaching Methods courses (Lumpe et al. 1998), which allow preservice teachers to combine beliefs about pedagogy (pedagogical knowledge and beliefs) and beliefs about content (content knowledge and beliefs). Preservice teachers can experience all of the sources of efficacy beliefs in this course. Therefore, well-designed Science Teaching Methods courses with inquiry-based SSI activities and cooperative learning, which would also develop communication skills, could be added to science teacher education programs in other contexts because they seem to effectively improve teaching efficacy beliefs about SSI (Palmer 2006). Another group of pedagogy courses is related to the teaching practicum in state schools. We suggest that preservice teachers should find opportunities to test their beliefs in these practices and to enact some of these beliefs. In these courses, preservice teachers experience all of the sources of teaching efficacy beliefs. Therefore, sending student teachers to state schools for practice is a useful suggestion to help future teachers develop strong teaching efficacy about SSI.

Although preservice teachers possess moderately high teaching efficacy beliefs about GM foods, the level of these beliefs decreases in cases of teaching NOS and incorporating families into teaching SSI. Because of their naive NOS beliefs, they struggle to transfer correct NOS beliefs to teaching SSI. Therefore, explicit NOS instruction activities (Akerson et al. 2000) in Turkish science teacher education programs and in other contexts can be suggested for a better NOS background that will facilitate stronger teaching efficacy beliefs about SSI. In addition, the effects of parents are apparent when teaching SSI. Science education policy makers must address ways to communicate with parents, explain the necessity of teaching these issues, request their participation, and consider local cultures.

Another important result of the present study is that preservice science teachers’ beliefs about GM foods and their beliefs about teaching this topic exist as a belief system. We suggest two important implications for policy makers. First, it seems that teacher educators and researchers can use risk perceptions, content knowledge, and core beliefs (epistemological beliefs about teaching and values that preservice teachers attach to science teaching) as indicators of teaching efficacy beliefs about SSI. Second, preservice science teachers must be aware of their belief systems, reflect on them, and consider their basis (Fives and Buehl 2012). Because belief systems are nonconsensual (Abelson 1979), peer discussion environments can be created in which preservice teachers can reflect on their belief systems.

Preservice teachers who lack strong teaching efficacy beliefs about SSI, for example, might explicitly learn from the perspectives of others and elaborate and integrate new information into their existing belief systems (Ertmer 2005; Kagan 1992).

At this point, we also feel concerned that some of the preservice science teachers with high-risk perceptions together with a desire to shape next generations may impose their understandings, risk perceptions, and points of views on their students. In other words, they may prefer a one-sided perspective while presenting the topics and managing the discussions. Similarly, some preservice science teachers with sophisticated knowledge background together with traditional epistemologies based on knowledge transfer may prefer addressing only the factual knowledge of SSI rather than a combination of knowledge, values, beliefs, and moral factors. Considering the necessity of inter-animation (Scott 1998) of different world views, ideologies and decision alternatives in SSI-based education, teacher educators, and curriculum makers need to effectively manage the power of core beliefs and beliefs about content that are direct or indirect motivators of preservice science teachers' efficacy beliefs about SSI. At this point, sophisticated epistemologies with strong knowledge background and manageable risk perceptions with strong motivation for raising scientifically literate generations may be optimal for teaching SSI and science.

The Items in Teacher Belief System Questionnaire

Content Knowledge About GM Foods

Genetically modified tomatoes include genes, whereas normal tomatoes do not.
One of the areas in which gene transfer is used in plants is producing disease resistance.
Genetically modified foods cannot be digested.
In order to modify the genes of a plant, its cells should be killed.
A plant's need for fertilizers and pesticides is decreased by changing its genetical structure.

Moral Beliefs About GM Foods

Buying GM foods instead of normal ones is against my personal principles.
I feel guilty if I buy foods produced by genetically modified organisms instead of other foods.
I do not find any problem with GM foods in terms of moral aspects.
Buying foods produced by genetically modified organisms instead of other foods makes me embarrassed.
I do not eat GM foods due to moral reasons.

Religious Beliefs About GM Foods

I think genetic modification of organisms is interfering with God's work.
Modification of the genetic structure of an organism is a sin.
I believe that people who change the genetic structure of organisms will be punished by God after they die.
I believe that people who change the genetic structure of organisms will be punished by God in this world.
Eating GM foods is a sin.

Risk Perceptions About GM Foods

To what extent will genetic modification lead to illnesses in future generations?
To what extent will genetic modification cause cancer?
To what extent will genetic modification have severe consequences?
To what extent is genetic modification a result of humans who destroyed the balance of nature?
How much will GM foods harm humans?
To what extent will the other people expose this risk?
How much will genetic modification lead to negative effects unknown today?
How much will genetic modification lead to negative irreversible effects?
How much will genetically modified organisms harm animals in nature?
How much will GM foods harm the environment?
How much will genetically modified organisms harm plants in nature?
To what extent do GM foods have risks that are not easily avoided?
How much is GM technology dreaded?

Teaching Efficacy Beliefs About GM Foods

There are different perspectives regarding the production of foods from genetically modified organisms. Some scientists say that there may be significant harm from these foods in the future in terms of health and the environment, whereas others say that this technology is risk-free and may be important to healthily and cheaply meet the food needs of a rapidly increasing population. About the political aspects of this technology, Turkey has allowed the use of genetically modified corn and soybeans in breeding livestock. Currently, GM foods are consumed in the USA, whereas EU countries have some restrictions. In contrast, consumers and environmental organizations approach these foods negatively. Some economists and representatives of ministries, such as the Ministry of Health and the Ministry of Forest and Agriculture, suggest that these foods would not cause problems. In addition, the media has a huge influence in disseminating information about GM foods. Some people think that the media do their job, and some think that the media exaggerate the risks. Suppose that the Ministry of Turkish National Education asks students to make informed decisions about the production, consumption, encouragement or restriction of GM foods. You plan a 3-h science course in which you attempt to teach the concepts and skills needed to make informed decisions and to discuss different perspectives. The following statements are possible competences we prepared for this course. Please choose one of the options that best represent your opinion of how much you can realize these competences and practices.
How well can you determine learning goals for this course?
How well can you assess whether students grasped the knowledge and concepts taught in this course?
How much can you do to get students to believe they can make informed decisions in their future?
How much can you do to keep students' attention during discussions?
How well can you use different teaching methods in teaching controversial issues, such as GM foods?
How much can you do to adjust the concepts and discussions about GM foods to the proper level for individual students?
How much can you do to motivate students who show low interest in the subject so they join the discussions?

How well can you teach decision-making skills in schools in rural places?
How well can you specify the need for teaching controversial issues to families?
How well can you incorporate families in teaching decision-making skills about these issues?
How well can you get your students to understand the fact that values and beliefs are important in explaining these issues?
How well can you teach how scientific knowledge is produced about GM foods?
How well can you get your students to learn the nature of aspects of the news about GM foods in the media?
How well can you explain the scientific experiments about GM foods?
How well can you respond to questions about GM foods to be raised by students?
To what extent can you provide an alternative explanation or example when students are confused?

References

Abelson, R. P. (1979). Differences between belief and knowledge systems. *Cognitive Science, 3*, 355–366.
Akerson, V. L., Abd-El Khalick, F., & Lederman, N. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching, 37*(4), 295–317.
Kılınç, A., Yesiltas, N.K., Kartal, T., Demiral, U., & Eroglu, B. (in press). School students' conceptions about biodiversity loss: Definitions, Reasons, Results and Solutions. Research in Science Education. doi:10.1007/s11165-013-9355-0.
Kılınç, A., Boyes, E., Stanisstreet, M. (2013). Exploring students' opinions about risks and bene"its of nuclear power using risk perception theories. *Journal of Science Education and Technology, 22*(3). 252–266.
Kılınç, A., Watt, H., & Richardson, P. (2012). Factors influencing teaching choice in Turkey. *Asia-Pasific Journal of Teacher Education, 40*(3), 199–226.
Bandura, A. (1997). *Self-efficacy in changing societies*. Cambridge: Cambridge University Press.
Bryan, L. A. (2003). Nestedness of beliefs: examining a prospective elementary teacher's belief system about science teaching and learning. *Journal of Research in Science Teaching, 40*(9), 835–868.
Bryce, T., & Gray, D. (2004). Tough acts to follow: the challenges to science teachers presented by biotechnological progress. *International Journal of Science Education, 26*(6), 717–733.
Christensen, C. (2009). Risk and school science education. *Studies in Science Education, 45*(2), 205–223.
Cresswell, J. W. (2008). *Educational research: planning, conducting and evaluating quantitative and qualitative research*. New Jersey: Pearson.
Cross, R. T., & Price, R. F. (1996). Science teachers' social conscience and the role of controversial issues in the teaching of science. *Journal of Research in Science Teaching, 33*(3), 319–333.
Day, S. P., & Bryce, T. G. K. (2010). Does the discussion of socioscientific issues require a paradigm shift in science teachers' thinking? *International Journal of Science Education, 33*(12), 1675–1702.
Dogan, N., & Abd-El-Khalick, F. (2008). Turkish grade 10 students' and science teachers' conceptions of nature of science: a national study. *Journal of Research in Science Teaching, 45*(10), 1083–1112.
Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham: Open University Press.
Eurobarometer (2010). *Europeans and biotechnology in 2010*: *winds of change*? A report to the European Commission's Directorate-General for Research.
Ertmer, P. A. (2005). Teacher pedagogical beliefs: the final frontier in our quest for technology integration. *Educational Technology Research and Development, 53*(4), 25–39.
Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S. S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Science, 9*, 127–152.
Fives, H., & Buehl, M. M. (2012). Spring cleaning for the 'messy' construct of teachers' beliefs: What are they? Which have been examined? What can they tell us? In: K.R. Harris, & T. Urdan (eds.) *APA educational psychology handbook*: *vol 2*. *Individual differences and cultural and contextual factors* (pp.471–499).

Fives, H. (2003). *What is efficacy and how does it relate to teachers' knowledge? A theoretical review*. Paper presented at the American Educational Research Association Annual Conference, April 2003, Chicago.

Fowler, S. R., Zeidler, D. L., & Sadler, T. (2009). Moral sensitivity in the context of socioscientific issues in high school students. *International Journal of Science Education, 31*(2), 279–296.

Gaskell, G., Allum, N., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., et al. (2004). GM foods and misperception of risk perception. *Risk Analysis, 24*(1), 185–194.

Hurriyet Daily News (2012). *Turks refusing to eat GM food, poll reveals*. http://www.hurriyetdailynews.com/turks-refusing-to-eat-gm-food-poll-reveals.aspx?pageID=238&nID=25045&NewsCatID=344. Accessed: 9 July 2012.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65–90.

Lee, H., Abd-El-Khalick, F., & Choi, K. (2006). Korean science teachers' perceptions of the introduction of socio-scientific issues into the science curriculum. *Canadian Journal of Science, Mathematics, and Technology Education, 6*(2), 97–117.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (1998). Science teacher beliefs and intentions to implement science-technology-society (STS) in the classroom. *Journal of Science Teacher Education, 9*(1), 1–24.

Mansour, N. (2008). The experiences and personal religious beliefs of Egyptian science teachers as a framework for understanding the shaping and reshaping of their beliefs and practices about Science-Technology-Society (STS). *International Journal of Science Education, 30*(12), 1605–1634.

McGinnis, J. R., & Simmons, P. (1999). Teachers' perspectives of teaching science-technology-society in local cultures: a sociocultural analysis. *Science Education, 83*(2), 179–211.

Nehm, R. S., Kim, S. Y., & Sheppard, K. (2009). Academic preparation in biology and advocacy for teaching evolution: biology versus non-biology teachers. *Science Education, 93*(6), 1122–1146.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317–328.

Pajares, F. (1992). Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research, 62*(3), 307–332.

Palmer, D. H. (2006). Sources of self-efficacy in a science methods course for primary teacher education students. *Research in Science Education, 36*, 337–353.

Pew Research Center (2011). *The future of the global Muslim population: projections for 2010–2030*. Pew Research Center's Forum on Religion & Public Life.

Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship: teaching socio-scientific issues*. Maidenhead: Open University Press.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625–637.

Rokeach, M. (1968). *Beliefs, attitudes, and values: a theory of organization and change*. San Francisco: Jossey.

Sadler, T. (2011). *Socioscientific issues in the classroom: teaching, learning and research. Contemporary trends and issues in science education* (Vol. 39). New York: Springer.

Scott, P. (1998). Teacher talk and meaning making in science classrooms: a Vygotskian analysis and review. *Studies in Science Education, 32*(1), 45–80.

Sjöberg, L. (2008). Genetically modified food in the eyes of the public and experts. *Risk Management, 10*, 168–193.

Sjöberg, L., Moen, B. E., & Rundmo, T. (2004). *Explaining risk perception: an evaluation of the psychometric paradigm in risk perception research*. Trondheim: Rotunde.

Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics*. NY: Collins.

Turkish Biosafety Council (2012). *Council decision 11*. http://www.tbbdm.gov.tr/home/biosafetycouncilhome/councildecisions/Biyog%C3%BCvenlik_Kurulu_Karar%C4%B1_11.aspx. Accessed: 20 August 2012.

Tsai, C. C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24*(8), 771–783.

Woolfolk, A. (2001). *Educational psychology* (8th ed.). Boston: Allyn and Bacon.

Yılmaz-Tüzün, O., & Topçu, M. S. (2008). Relationships among preservice science teachers' epistemological beliefs, epistemological worldviews and self-efficacy beliefs. *International Journal of Science Education, 30*(1), 65–85.

Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: theory and practice. *Journal of Elementary Science Teacher Education, 21*(2), 49–58.