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Preservice Science Teachers' Belief Systems about Teaching a Socioscientific Issue

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ABSTRACT

We investigated the belief system of Turkish preservice science teachers (PSTs) about teaching a socioscientific issue (GM Foods) using a belief system model. This model includes three belief pools: content beliefs (CBs), core pedagogical beliefs (CPBs) and pedagogy of content beliefs (PCBs). Based on this model, we developed a questionnaire in order to see interrelationships among three belief pools about teaching GM Foods. For content beliefs, we selected content knowledge, risk perceptions, moral beliefs and religious beliefs. For pedagogy of content beliefs, we selected teaching efficacy, preferred teaching methods and preferred teacher's roles. We administered the questionnaire to 423 PSTs. Using correlation analysis, multinomical logistic regression and structural equation modelling we tried to understand the relationships between CBs and PCBs and to make interpertations about possible CPBs working as a filter between CBs and PCBs. The results show that PSTs are relatively knowledgeable, hold high risk perceptions and certain moral and religious beliefs about GM Foods. They possess high teaching efficacy beliefs, choose the teaching role of Neutral Impartiality and prefer large class discussion and computer-assisted teaching. As core pedagogical beliefs (CPBs), they may have traditional epistemologies, moral and religiously-based teaching goals.

Keywords: Belief System; Teaching Socioscientific Issues; Preservice Science Teachers; Turkey.

INTRODUCTION

Genetically Modified (GM) foods, nuclear plants, cloning and global warming occupy international agendas more than ever before. These issues are controversial and lack clear-cut answers and decision alternatives. Therefore, all stakeholders (i.e., scientists, government bodies, representatives of industry and, in particular, the public) have different points of view,

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ideologies and beliefs. These contemporary societal and scientific topics are referred to as socioscientific issues (Driver et al., 1996). Many countries are attempting to engage with these issues through policy development, *perhaps because of their economic significance*. For instance, the European Union has addressed socioscientific issues (SSI) through the development of responsible research and innovation as a fundamental policy (European Union [EU], 2012). Turkey, in three vivid examples of SSI, has established two new nuclear plants and invested in space and military technologies and in genetically modified (GM) foods.

On the other hand, in addition to the economic significance of SSI, governments realised that public understanding of these issues is crucial after many of the policies that did not account for public opinion failed (EU, 2012). The banning of DDT and closure of nuclear plants in different countries are only two results of such ill-structured policies. Therefore, *many countries began to prioritise raising public awareness about these issues*. They have incorporated SSI into national curricula so that school students, future citizens, can make informed decisions about them (Dawson, 2001).

There is sufficient evidence to argue that SSI-learning yields positive learning outcomes that are favourable to government goals. In SSI-based courses, school students learn how to collect and analyse data, build and defend strong arguments, develop decision-making skills, address moral dilemmas and develop their moral sensitivity (Sadler, 2011a). However, these learning environments have been designed either by researchers or by science teachers with the guidance of scholars (Sadler, 2011a). Consistent with this idea, *many science teachers in countries that underwent SSI curriculum reform argue that teaching SSI is challenging and requires a new set of teaching skills,* such as giving authority to students, dealing with uncertainties and discussing moral and emotional perspectives (Oulton, Dillon & Grace, 2004).

Turkey revised its science curriculum using SSI-based education in February 2013, when the Turkish Ministry of Education (TME) updated its science teaching programme. The development of scientific habits of mind using SSI is now one of the 12 basic goals of Turkey's science teaching programme (TME, 2013). However, most of these new developments are not yet reflected in teaching materials, textbooks or in preservice and in-service teacher education programmes. Currently, Turkish science teachers present SSI topics in unplanned learning environments because they do not know how to address these issues (Author, 2012a). In the present study, we focused on PSTs who must apply SSI perspectives in their classrooms under recent curriculum reform. *Taking a closer look at PSTs, we aimed to measure the possible success of SSI educational reform in Turkey.*

Furthermore, studies on SSI-based science teaching and teachers' perspectives are, to date, limited, and the literature focuses on knowledge types (subject matter or pedagogical content) (vanderZande et al., 2012) and individual beliefs such as goals for teaching SSI (Jones & Carter, 2007), teaching efficacy beliefs (Lee, Abd-El-Khalick& Choi, 2006) and the intention to use SSI (Sadler et al., 2006). At this point, *a theoretically sound approach - such as one using the model of 'belief system' - will provide stronger results about the nature of teachers' approaches and beliefs* (Pajares, 1992). Thus, in the present study, we focused on preservice science teachers' belief system about a socioscientific issue.

Teaching SSI

Scholars agree that science teachers usually have positive attitudes towards incorporating SSI into their teaching programmes (Lumpe, Haney &Czerniak, 1998). Teachers believe that addressing SSI in classrooms gives them the opportunity to promote democratic participation and social justice and to raise scientifically literate citizens (Jones & Carter, 2007). They also stress that teaching SSI helps students understand scientific concepts, apply science to everyday life and develop decision-making skills (Ekborg et al., 2013).

However, despite this positive affect, many teachers do not enact their beliefs in practice and do not address SSI in a systematic manner (Author et al., 2012a). Students usually raise topics in their classrooms, and their teachers respond quickly (Sadler et al., 2006) with informal discussions of poor quality (Day & Bryce, 2010). In addition, teachers spend little time on these discussions (Lee et al, 2006).

The existing literature shows that low level of efficacy beliefs among teachers (Lee et al., 2006), incorrect roles during SSI teaching (Simmonneaux, 2007) and inappropriate teaching methods (Author 1 et al., 2012a) are responsible for these negative results. Below, we discuss each component in detail.

Teaching Efficacy Beliefs about SSI Education

Bandura (1997) defines self-efficacy as 'beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments' (p.3). A teacher's self-efficacy implies 'a teacher's belief that he or she can reach even difficult students and help them learn' (Woolfolk, 2001, p.389). Teachers with a high sense of efficacy work harder and persist even when students are difficult to teach; they are also strong motivated in helping their students learn (Bandura, 1997).

There are a few studies about self-efficacy beliefs associated with teaching SSI. Lee, Abd-EI-Khalick and Choi (2006), for example, stressed that Korean science teachers do not have a strong sense of efficacy about teaching SSI. They found SSI different from other topics in the science curriculum because there are no clear-cut answers to the queries they posed for students. Similarly, Reiss (1999) reported that science teachers feel under-equipped to teach ethical and moral questions. In addition, Bryce (2004) noted that teachers do not feel they are experts on these issues and said that a 'messy' science curriculum was a time-consuming obstacle to teaching.

Teachers' Roles in SSI Education

Kelly (1986) identified four teachers' roles in teaching controversial topics: Exclusive Neutrality, Exclusive Partiality, Neutral Impartiality and Committed Impartiality. In Exclusive Neutrality, teachers do not introduce controversial issues into the broader community or share opinions on such topics. These teachers see scientific knowledge as the key and avoid potential problems in teaching SSI by sticking to facts (Oulton et al., 2004).

In Exclusive Partiality, teachers aim to convince students to adopt a correct position on controversial issues and share their views to persuade students to accept their own perspectives. In SSI teaching, Lemke (1990) considers that power relations in science classrooms may contribute to this effect. Ratcliffe and Grace (2003) note that teachers in this group use strategies to show their bias, such as presenting their opinions as facts and highlighting a particular set of facts that support their opinions.

In Neutral Impartiality, the teacher promotes classroom discussion and does not reveal his/her position on SSI. Rather than impose an opinion, the teacher aims to present different opinions that can assist in making decisions about SSI. Most in-service and PSTs prefer this role (Oulton et al., 2004). They suggest that they aim to provide a balanced experience and a range of opinions so that students can make up their own minds and develop their own value systems. Certain teachers in this group believe that they should provide equal information about all perspectives on an SSI (Sadler et al., 2006), in terms of both quality and quantity (Cross & Price, 1996).

In Committed Impartiality, the teacher promotes classroom discussion, discloses his/her opinions on controversial topics and encourages students to do the same. The goal is to model a thinking process, not to advocate an outcome. Certain science teachers would like to present different perspectives neutrally but believe it is impossible to avoid revealing their views and values. Therefore, they prefer to explain their positions without imposing them on students; thus, they aim to be a role model for adult decision-making and argumentation (Simmoneaux, 2007). Certain scholars (Kelly, 1986; Oulton et al., 2004) suggest that Committed Impartiality is the best role in SSI teaching.

Teaching Methods in SSI Education

Scholars (e.g., Sadler, 2011b) believe that teaching SSI requires collaborative and interactive classroom environments, where students and teachers feel safe and demonstrate mutual respect. Although most current science teachers' practices do not create these classroom environments (Lee et al., 2006; Sadler et al., 2006), empirical research (e.g., Sadler, 2011a) that assisted teachers in designing SSI-based classroom environments showed that certain existing teaching methods fit with SSI teaching.

The following teaching methods yield positive learning outcomes in SSI teaching: online modules based on student discussion, field trips (Tal et al., 2011), role playing, small group discussions and debates (Sadler, 2011b), drama (Aikenhead, 2006), case studies based on real contexts (Driver et al., 1996), problem based learning (Keefer, 2003), ethical and moral dilemmas (Zeidler& Lewis, 2003) and preparation of media reports (Ratcliffe& Grace, 2003). In addition, classrooms benefit from didactic teaching (i.e., lecturing), lab exercises and, to some extent, guided inquiry (Sadler, 2011b).

Teachers' Belief Systems about SSI Teaching

Empirical and theoretical work has shown that teachers' beliefs exist as a system (Fives &Buehl, 2012). Because they are insiders of education (Pajares, 1992), they develop many beliefs about learning and teaching even in precollege education (Borko& Putnam, 1996). These beliefs are incorporated into a complex network that includes core and peripheral beliefs. Core beliefs are usually more resistant to change relative to the peripheral ones (Fives &Buehl, 2012).

Author and colleagues (2013) argued that teachers possess a belief system that incorporates the three types of beliefs: content beliefs (CBs), core pedagogical beliefs (CPBs) and pedagogy of content beliefs (PCBs). They used the theoretical assumptions of Abelson (1979) and Rokeach (1968) to support this belief system model. The unbounded nature of beliefs suggested by Abelson (1979) helped them to understand the relationships between different beliefs in the same system. Accordingly, they argued that teachers' CBs, CPBs and PCBs are strongly interrelated because the boundaries among these beliefs are uncertain. For instance, a teacher with strong pessimistic beliefs about building nuclear plants (CBs) may try to impose his or her point of view when teaching nuclear energy (PCBs). Similarly, a teacher with naive epistemologies about the nature of knowledge (CPBs) may choose didactic methods when teaching cloning (PCBs).

Using Rokeach's (1968) opinions about belief segmentation (Types of Beliefs), Author and collaborators (2013) also determined two levels of belief in a system. CBs and PCBs were peripheral, whereas CPBs were the core beliefs underlying peripheral ones. Core beliefs can be epistemologies, beliefs about the Nature of Science (NOS) and teaching goals. Author and colleagues (2013) argued that CPBs work as a filter between CBs and PCBs eventhough they believed that there may also be direct relationships between peripheral beliefs.

To test the concept of belief systems, Author and colleagues (2013) designed a mixed study focused on a socioscientific issue: GM foods. Their model included two pools of beliefs, which were CBs and PCBs. As CBs, they identified content knowledge, risk perceptions, moral beliefs and religious beliefs about GM foods. For PCBs, they used teaching efficacy beliefs. They first prepared specific questionnaires targeting the belief types in their model and administered them to 445 PSTs. The quantitative results showed that content knowledge and risk perceptions were positive and significant predictors of teaching efficacy. Follow-up interviews with eight participants identified that traditional epistemologies, such as knowledge transfer, explained the relationships between knowledge and teaching efficacy. In addition, the task values (or goals) of teaching science, such as a desire to shape future generations, were responsible for the relationships between risk perceptions and teaching efficacy. Therefore, they incorporated these CPBs into their belief system model (for further information, please see Author, 2013).

An Extended Belief System Model for Understanding Beliefs about Teaching a Socioscientific Issue

The proposed belief system model in the present study is shown in Figure 1. We extended the set of PCBs by adding two new dimensions: beliefs about teacher's roles in SSI teaching and beliefs about methods in teaching GM foods. We used the same CBs that we used in our previous research (Author, 2013). Our goal was to retest the belief system model for SSI teaching by extending it. This test will also provide us stronger information about the nature of teachers' belief systems in SSI teaching. Such information can be used in preparing more efficient curricula for preservice teacher education and professional development oppurtunities for current teachers.

Our criteria for selecting CBs were a high frequency for each parameter in the literature and the potential impact of these parameters on the PCBs. For beliefs related to GM foods, we selected content knowledge, religious beliefs, moral beliefs and risk perceptions, which we identified as important content-specific beliefs in understanding SSI and decision-making (EuroBarometer, 2010). For the PCBs, we identified teaching efficacy beliefs, beliefs about teachers' role in SSI teaching and beliefs about teaching methods in SSI teaching that were problematic and that became important bariers before successful SSI teaching. In addition, as scholars (Lee et al., 2008; Oulton et al., 2004; Sadler, 2011) suggest, we consider these three dimensions to be crucial in decisions about SSI teaching, teaching material preparation, the management of student learning and the achievement of learning outcomes such as higher order thinking skills and ethical reasoning.

We believe that PCBs are, of all belief types, the closest to real classroom practices. These professional beliefs are usually formed when teachers enter teacher training, and we hold that personal CBs and CPBs shape these beliefs. In the present study, we firstly investigate the relationships between CBs and PCBs. These relationships help us to elicit CPBs as Author (2013) suggested that these beliefs work as a filter between peripheral beliefs. We believe that identifying three types of beliefs in the same belief system will allow us to find significant educational implications for SSI reform in Turkey and in similar contexts.

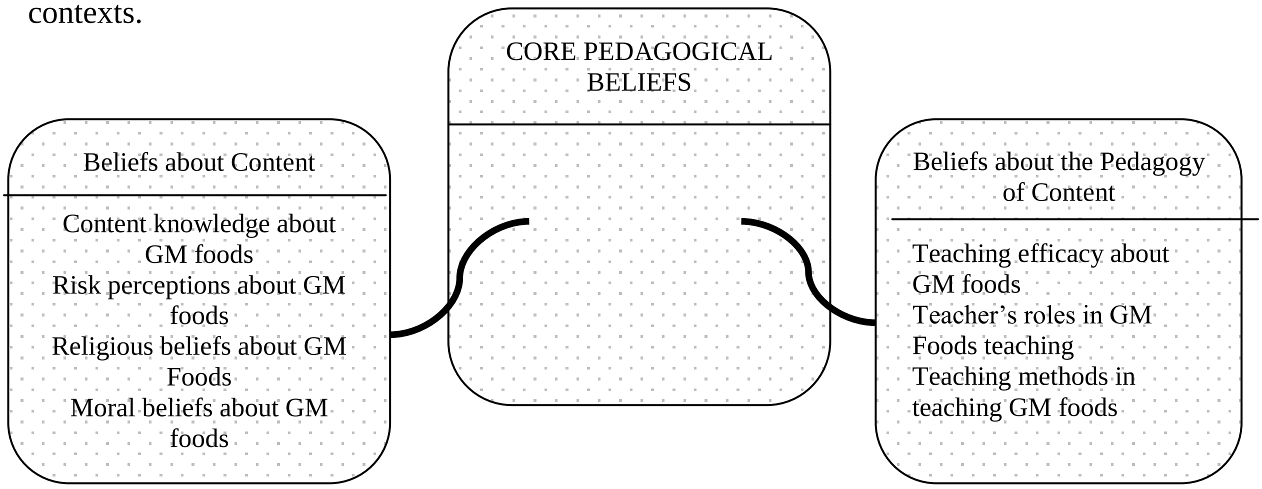

Figure 1. *Theoretical Belief System for Teaching about GM Foods*

The purpose of this research is to investigate Turkish preservice science teachers' belief systems about teaching GM foods. We attempted to answer the following research questions:

1. What types of relationships exist in preservice science teachers' belief systems about teaching GM foods?
2. To what degree does the belief system model (Figure 1) reveal the contributions of factors related to belief systems in the teaching of GM foods?

METHODOLOGY

We organized a quantitative research based on correlation and regression models in the present study.

a) Sample

We selected PSTs from ten universities with Teaching Science departments in different regions of Turkey as our sample using convenience sampling procedures. These universities offer same science teacher education curricula with slight changes permitted by Higher Education Council. The science teacher education in Turkey takes four year. The PSTs take a range of content (e.g., Physics), pedagogy (e.g., Educatinal Pscyhology) and pedagogy of content courses (e.g., Specific Teaching Methods). Our sample included 423 (127 [30 %] male and 296 [70 %] female) PSTs with a mean age of 21.5 (SD=1.39, range=18-27). In addition, we selected participants in their third and fourth years of study because they had taken many pedagogical and science courses. Of the sample, 262 (62 %) participants were in Year 3 and 161 participants (46.3 %) in Year 4.

b) Development of Belief System Questionnaire

We developed a Teacher Belief System Questionnaire (TBSQ) using the belief system model in Figure 1. The TBSQ included eight sub-questionnaires: Content Knowledge about GM Foods (CKGF), Moral Beliefs about GM foods (MBGF), Religious Beliefs about GM Foods (RBGF), Risk Perceptions about GM foods (RPGF), Teaching Efficacy Beliefs about GM Foods (TEBGF), Teachers' Roles in Teaching GM Foods (TRTGF), Efficacy Beliefs about Teaching Methods (EBTM) and Effectiveness Beliefs about Teaching Methods in Teaching GM Foods (EBTMTGF). The questionnaire was preceded by a cover sheet requesting personal information, such as gender, age, university and year group. The items in the TBSQ are shown in Appendix.

We selected items based on questionnaires that are frequently used in the literature (see Table 1). In the development of TEBGF, we also conducted semi-structured interviews with six experienced science teachers regarding their teaching efficacy beliefs about SSI. These interviews targeted teachers' understandings of SSI, actual teaching experiences, confidence in teaching these topics and the sources of their teaching efficacy (Author, 2013).

In the section of the questionnaire dealing with teachers' role in SSI teaching, we used Kelly's (1986) teacher's roles (Exclusive Neutrality, Exclusive Partiality, Neutral Impartiality, Committed Impartiality) in teaching controversial topics. We prepared a scenario to represent each role and asked the PSTs to choose one of them (Author, in submission).

We investigated the potential use of a teaching method in teaching GM foods in two final parts of the questionnaire. The first part (EBTM) included 25 teaching methods (e.g., didactic teaching), and we asked PSTs how well they could use these methods. In the second part (EBTMTGF), we relisted the same teaching methods and asked the PSTs to evaluate how effective these teaching methods would be in teaching SSI.

After the selection of items, we held a meeting with sixteen 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 questionnaire development, a reading education professor, a lecturer from the Turkish Language and Literature department, three doctoral students and six Master's students. This group scrutinised the items and the layout of the sub-questionnaires in terms of content and language. Minor changes were made to some items.

After pilot tests with large samples, we reached the final versions of the sub-questionnaires in Table 1. The alpha reliability scores of the sub-questionnaires ranged from 0.61 to 0.91.

Table 1. *Information about the Sub-Questionnaires in TBSQ*

Sub-questionnaire	Abbreviation	Number of items	Available responses	Item sources
Content Knowledge about GM Foods	CKGF	5	True, False, Don't Know	Eurobarometer (2010) Sjöberg (2008)
Risk Perceptions about GM Foods	RPGF	13	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	4	I completely disagree, I disagree, I neither agree nor disagree, I agree, I completely agree	Eurobarometer (2010)
Religious Beliefs about GM Foods	RBGF	5	I completely disagree, I disagree, I neither agree nor disagree, I agree, I completely agree	Eurobarometer (2010)
Teaching Efficacy Beliefs about GM Foods	TEBGF	10	Nothing (1).... A great deal (9)	Riggs &Enochs (1990) Semi-structured interviews
Teachers' Roles in Teaching GM Foods	TRTGF	4	Role 1, Role 2, Role 3, Role 4	Kelly (1986)
Efficacy Beliefs about Teaching Methods	EBTM	25	Never (1)… Very (5)	Yilmaz-Tuzun (2008)
Effectiveness Beliefs about Teaching Methods in Teaching GM Foods	BTMTGF	25	Never (1)… Very (5)	Yılmaz-Tuzun (2008)

c) Administration of the Teacher Belief System Questionnaire (TBSQ)

We identified a lecturer contact in each programme, and, before administering the questionnaire, the authors initiated phone conversations with the contacts to inform them about the aims of the study, to identify possible questions from the participants and to explain the administration procedure. Almost all of the lecturers distributed the questionnaires in their regular classrooms and allowed time for the clarification of participants' queries. The participants completed the questionnaires in approximately 25 minutes.

d) Data Analysis

We used various descriptive and inferential analyses in the present study. Descriptive statistics were used to understand the psychometric factors of GM foods and the teaching of this topic. We used structural equation modelling (SEM) as an inferential analysis to test the relationships between CBs and teaching efficacy beliefs. We controlled the assumptions of SEM such as normality, random missing data and model specification. To find the predictors of beliefs about teachers' roles in teaching SSI, we used Multinomial Logistic Regression (MLR). In addition, we tried to understand the potential use of a teaching method in SSI education with a scatter gram, which was plotted using the mean scores of the responses to questionnaire items in the first part (efficacy beliefs) against the mean scores of the responses to the items in the second part (effectiveness beliefs). To measure the relations between CBs and beliefs about teaching methods, we used Pearson Moments Correlations and correlated the CBs with the effectiveness beliefs about teaching methods in SSI education.

FINDINGS

Beliefs about Gm Foods (CBS)

Content Knowledge about GM Foods: We found that the participants were relatively well informed about GM foods. 58 % of the participants answered all of the items correctly. Many participants were aware of focus areas for genetic modification, such as development of resistant species, and the basic techniques of GM food production.

Risk Perceptions about GM Foods: The participants considered GM foods risky, most commonly reporting this idea with the responses 'To some extent (4)' and 'To a high degree (5)'. They agreed that GM foods are the result of humans' negative impact on nature (M=4.82, SD=1.15). They also believed that these foods present a serious risk to human health, and the risks with high mean scores were illnesses in future generations (M = 4.86, SD=1.08) and cancer (M = 4.88, SD=1.13). Other items also had relatively low mean scores: items related to the severity of GM foods (M = 4.43, SD=1.14) and the harmful effects of GM foods on plants (M = 4.41, SD=1.21).

Moral Beliefs about GM Foods: The participants held certain moral beliefs about GM foods, which varied according to different items. In terms of emotional aspects, a small proportion (31%) of the participants reported that they would feel guilty if they preferred GM foods to other foods, whereas about a half (44 %) said that they would feel embarrassed. Only a quarter (26%) believedthat buying GM foods would conflict with their principles. However, approximately half (44 %) said that they would not eat GM foods for moral reasons.

Religious Beliefs about GM Foods: The participants in this study had moderate religious beliefs. More than half (58 %), for example, thought that eating GM foods was a sin. Similarly, 45 % believed that genetic modification was a sin. In addition, 45 % agreed that the genetic modification of organisms interfered with God's work. A similar proportion of the participants believed that the people who performed genetic modifications would be punished by God during their lifetime (51 %) or after their death (45 %).

Beliefs about Pedagogy of GM Foods (PCBs)

Teaching Efficacy Beliefs: Based on the descriptive results in Table 2, we can argue that the participants had moderately high efficacy beliefs about teaching GM foods. All of the items had mean scores over 6 and in the range of 1-9. On one hand, the participants strongly believed that they could hold their students' attention during discussions and develop their thinking skills. On the other hand, preparing materials and scenarios, using different teaching methods and teaching ethical reasoning had lower mean scores.

Table 2. *Descriptive Results for Teaching Efficacy Items*

Items	Mean	Std Deviation	Range
How well can you prepare scenarios and materials for discussions?	6,02	1,64	1-9
How well can you use different teaching methods in teaching controversial issues, such as GM foods?	6,22	1,48	1-9
How well can you teach your students to reason ethically about genetic modification?	6,23	1,64	1-9
How well can you respond to student questions about GM foods?	6,31	1,61	1-9
How well can you implement the necessary steps to teach ideas about GM foods?	6,32	1,52	1-9
How well can you determine the learning goals for this course?	6,33	1,46	1-9
To what extent can you provide an alternative explanation or example when students are confused?	6,38	1,51	1-9
How well can you help your students to be aware of different opinions and beliefs about GM foods?	6,39	1,67	1-9
To what extent can you develop students' higher order thinking skills during discussions about GM foods?	6,41	1,31	1-9
How well can you hold students' attention during discussions?	6,57	1,43	1-9

Based on the belief system model in Figure 1, we assumed that CBs (content knowledge, moral beliefs, religious beliefs and risk perceptions) would affect teaching efficacy beliefs about GM foods. Our theoretical structural model based on this belief system is displayed in Figure 2.

Because the proposed structural relationships between the parameters can be conducted with a SEM analysis, we analysed all the participant responses 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 is acceptable from an empirical point of view. Considering the fit indices (chi-square = 1624.573, chi-square per degree of freedom = 2.626, RMSEA = .062, NFI = .80, TLI = .85, CFI = .87), we can say that the theoretical structure has a strong model fit (Tabachnick& Fidel, 1996).

Figure 2 also shows the summary of the maximum likelihood parameter estimates (standard coefficients) and the significance of the t-values, indicated by asterisks. Knowledge (content knowledge about GM foods) and risk (risk perceptions about GM foods) were significant predictors of the variation in SEB (Self Efficacy Beliefs about teaching GM foods). Religious beliefs (beta= .07) and moral beliefs (beta=.01) had small and nonsignificant relations with teaching efficacy beliefs. In addition, the independent variables were significantly correlated between -.33 and .37.

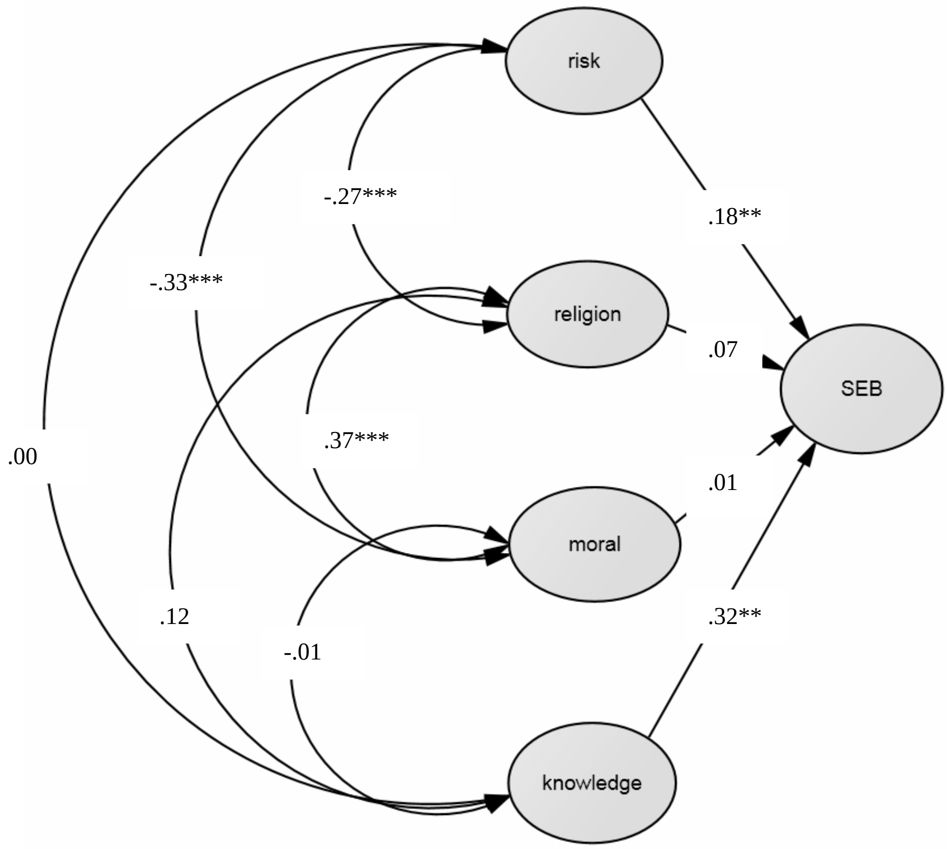

Figure 2. *Theoretical Structural Model Based on the Belief System in Figure 2 and Maximum Likelihood Parameter Estimates* (**: p <0.01, ***: p<0.001, risk: risk perceptions about GM foods; religion: religious beliefs about GM foods; moral: moral beliefs about GM foods; knowledge: content knowledge about GM foods; SEB: Self-efficacy beliefs about teaching GM foods).

Teachers' Roles in SSI Education: The results showed that 34 (9.3 %) participants selected Exclusive Neutrality, 34 participants (9.3 %) Exclusive Partiality, 204 (55.9 %) participants Neutral Impartiality and 93 (25.5 %) participants Committed Impartiality.

To test the model in Figure 1, we used Multinomial Logistic Regression (MLR). This type of regression enables the prediction of categorical dependent variables with either nominal or ordinal independent variables. The categorical dependent variable in our model was the selection of one of four roles for teachers in SSI education. The nominal independent variables were mean scores of content knowledge, religious beliefs, moral beliefs and risk perceptions. In MLR, the parameters are interpreted using odds ratios, whichrepresent the odds that an outcome will occur with a particular exposure compared to the odds of the same outcome occurring in its absence (Szumilas, 2010). Odds ratios over 1.0 indicate an increased likelihood, whereas ratios between 0 and 1 indicate a decreased likelihood. We set Committed Impartiality as the reference category because it is the role that many scholars (Oulton et al., 2004; Simmonneaux, 2007) suggested during SSI discussions. The results ofthe MLR are displayed in Table 3. We also provide descriptive results about each role in Table 4 to clarify the results of the MLR.

Table 3. *MLR Results*

	Likelihood ratio tests			P value			Odds ratios		
	Chi-square	df	sig.	EN	EP	NI	EN	EP	NI
Knowledge	6.899	3	.075	.113	.052	.943	.25	.21*	1.04
Religion	38.373	3	.000	.000	.011	.948	**.23*** **	**.50***	.99
Moral	23.939	3	.000	.006	.001	.629	**2.13****	**2.55*****	.92
Risk	4.822	3	.185	.049	.115	.209	**.54***	.65	.79

The reference category: Committed Impartiality (CI)
Model fit criteria: -2 log likelihood = 775.794, chi-Square =62.856, df = 12, p < 0.01, Nagelkerke R = .19, *p <0.05, **p<0.01, *** p<0.001

Table 4. *Descriptive Results about Each Role*

	Knowledge		Moral Beliefs		Religious Beliefs		Risk Perceptions	
	M	SD	M	SD	M	SD	M	SD
Exclusive Neutrality	.69	.28	**3.19**	.94	**2.78**	.83	**4.65**	.58
Exclusive Partiality	.66	.31	**3.50**	1.00	**3.36**	.87	4.70	1.28
Neutral Impartiality	.77	.26	2.88	.82	3.52	.92	4.67	.72
Committed Impartiality	.77	.26	**2.98**	.86	**3.59**	.91	**4.80**	.74

Our results show that religious beliefs, moral beliefs and risk perceptions were significant predictors in the selection of teachers' roles. The participants who held strong religious beliefs were 0.23 times less likely to select Exclusive Neutrality and 0.50 times less likely to choose Exclusive Partiality, compared to the Committed Impartiality reference group. In other words, the participants who had a lower level of religious beliefs than the ones who chose Committed Partiality selected Exclusive Partiality and Exclusive Neutrality.

Furthermore, the participants who reported strong moral beliefs were 2.13 times more likely to select Exclusive Neutrality and 2.55 times more likely to choose Exclusive Partiality, compared to Committed Impartiality. Thus, the participants who had stronger moral beliefs than the ones who selected Committed Impartiality selected Exclusive Partiality and Exclusive Neutrality. In addition, the participants with high risk perceptions were 0.54 times less likely to select Exclusive Neutrality than the Committed Impartiality group.

Overall, the characteristics of the participants who selected Neutral Impartiality and Committed Impartiality were similar for all the independent variables (i.e., knowledge, moral beliefs, religious beliefs and risk perceptions). The participants with less religious beliefs tended to select Exclusive Neutrality and Exclusive Partiality. In addition, the ones who selected Exclusive Neutrality and Exclusive Partiality held stronger moral beliefs than the other groups. Finally, the participants who selected Exclusive Neutrality had the lowest risk perceptions of all the groups.

Teaching Methods in SSI Education: In the scatter gram in Figure 3, the teaching methods located in the upper part of the (those with a higher mean score) are considered effective in GM food teaching by many students, whereas the methods in the lower part are considered less effective. Similarly, the teaching methods to the left of the plot were identified by the participants as inefficient, and those to the right were identified as efficient.

Looking at the positions of the various teaching methods on the plot, it can be seen that didactic teaching was not viewed as suitable for GM Foods teaching. Although the participants considered that inviting experts to classroom would be useful in teaching GM Foods, the efficacy of this method was limited.

Because the scales of efficacy and effectiveness included five response alternatives (from low (1) to high (5)), we believe that the responses over 4 for both scales can be used to find teaching methods with the highest use potential. We used the lines to show these teaching methods. Accordingly, it seems that the participants would use large class discussions and computer assisted teaching in their future careers because they identified these methods as efficient and effective in teaching GM foods. Collaborative and inquiry-based teaching methods (i.e., project based learning, inquiry, problem based learning, cooperative learning and case method) follow these methods in the list of PSTs. In addition, the PSTs showed high efficacy beliefs for lab-based activities and question-answer sessions even though they reported relatively limited effectiveness beliefs. In addition, PSTs believed that the methods about teaching conceptions such as analogy, 5E learning cycle, conceptual change texts and concept maps would not be useful as much as other methods would be in teaching SSI. Regarding role-play and drama, which are suggested methods for SSI-education, they considered these methods to be useful in teaching GM Foods to some extent but reported a limited efficacy in using them.

To measure the relations between CBs and beliefs about teaching methods, we used Pearson Moments Correlations. We investigated the relationships between CBs and beliefs about the effectiveness of each teaching method in teaching GM foods. Table 5 shows that risk perceptions were positively correlated with beliefs about the effectiveness of certain teaching methods. However, the correlation scores did not exceed .200, meaning that risk perceptions had weak relationships with the effectiveness of teaching methods. Apart from a few exceptions, the other content beliefs did not correlate with effectiveness beliefs.

DISCUSSION

In the case of CBs, we found that the PSTs were relatively knowledgeable and held certain moral beliefs, moderate religious beliefs and high risk perceptions. Apart from religious beliefs, the results about the CBs were consistent with our previous research (Author 1, 2013). It is possible that undergraduate courses, such as Specific Issues in Biology and Genetics, as well as media coverage are responsible for the sample's relatively strong conceptual background in GM Foods. In addition, the PSTs in this sample had stronger religious beliefs than did those in previous research (Author 1, 2013). It is hard to explain this result because the PSTs are from different regions and backgrounds across the universities. It is possible that genetic modification is a new topic for the religious authorities, and there is not yet any confirmation for its use, which causes it to be of interest to people with moderate religious beliefs. In addition, the new and unknown nature of these foods (Sjöberg, 2008) may be the reason for high risk perceptions in Turkey.

In terms of PCBs, the PSTs reported relatively high teaching efficacy beliefs. They commonly chose the role of Neutral Impartiality and preferred large class discussions and computer assisted teaching as teaching methods. Although this picture seems optimistic for the future of SSI reform in Turkey, we believe that further investigations are essential.

In the case of teaching efficacy beliefs, we noted that PSTs' efficacy beliefs were high for general instructional practices, such as holding student attention, but that efficacy decreased in the cases of preparing discussion scenarios and teaching ethical reasoning, which are specific components of SSI-based education. Similarly, Author (2013) found that PSTs were not confident in teaching the nature of science or in incorporating families into learning, which are specific elements of SSI teaching. It is possible that PSTs use general science teaching efficacy to interpret the items about teaching SSI and that this efficacy does not represent the beliefs about SSI teaching (Author, 2013). In addition, content knowledge and risk perceptions were positive significant predictors of teaching efficacy. Although certain studies show similar relationships (Cakiroglu& Boone, 2002), Author's (2013) comments are crucial for understanding these relations. Consistent with their arguments, we believe that certain CPBs influence these relations. In the case of content knowledge, traditional epistemologies based on knowledge transfer might come into play because most Turkish PSTs have naïve beliefs about learning and teaching knowledge (YılmazTuzun & Topcu, 2008). The PSTs with a strong knowledge background and naïve epistemologies based on knowledge transfer might believe that they can teach SSI efficiently. Regarding risk perceptions, a teaching goal such as the desire to raise a healthy generation might be influential because Turkish PSTs are sensitive about the social utility of teaching (Author, 2012b). Author (2013) found that PSTs believed that their risk perceptions led them to teach these topics effectively due to potential for health problems in the near future. Similarly, the PSTs in the present study with high risk perceptions and a desire to foster a healthy society might develop high teaching efficacy beliefs so that their students can better learn about the negative sides of GM Foods.

Regarding teachers' roles in SSI education, it was encouraging to find that only a small percentage of the PSTs chose Exclusive Neutrality (Role 1) and Exclusive Partiality (Role 2). This finding implies that most of the PSTs will incorporate SSI into their teaching without imposing their personal opinions. Although a large portion of PSTs selected Neutral Impartiality, the existing literature and we suggest this result might be an illusion. Many scholars (Kelly, 1986; Oulton et al., 2004; Simmonneaux, 2007) argue that most teachers and PSTs prefer this role before real teaching experience but soon change their role due to the impossibility of not disclosing personal values and opinions in the classroom. In addition, Author (in submission) noted that one of the reasons for choosing Neutral Impartiality was the desire to reach absolute truths by discussing different perspectives, which is an immature belief. They associated this result with the naive epistemologies of Turkish PSTs about certainty of knowledge. In addition, about a quarter of the sample selected the teaching role of Committed Impartiality. This proportion is similar to the results found in a previous study (Author, in submission). We believe that certain PSTs may have concerns about this role, such as the risk of influencing school students with their personal opinions and/or the possibility for difficult and unplanned debates (Author, in submission).

We believe that the predictors for the set of CBs strengthen our comments about beliefs in teachers' roles because, using them, we may identify CPBs. For example, the PSTs with higher religious beliefs preferred Neutral Impartiality or Committed Impartiality. They reported that they would incorporate SSI into their democratic learning environments without imposing their points of view on their students, though they may make their opinions explicit. Religiously based CPBs may come into play in this finding. Regarding creating a democratic environment highlighted in both Neutral Impartiality and Commited Impartiality, Islam, the Koran and the practices of Prophet Muhammad emphasise that there should be no pressure on people while they make their decisions. An individual should tell his/her opinion about a controversial issue but leave the decision to others (Esposito & Voll, 1996). Regarding being a model in Committed Impartiality, we can argue that modelling is crucial in Islam, especially while raising children, who learn what to do and not to do from observing models around them (Esposito & Voll, 1996). In addition, the PSTs with stronger moral beliefs particularly selected Exclusive Neutrality and Exclusive Partiality. This finding may imply that if a PST is convinced that GM foods are good or bad, he/she will not create a democratic environment that permits the discussion of possible alternatives, as in the roles of Neutral Impartiality and Committed Impartiality. These teachers will either avoid incorporating SSI into their teaching or impose their points of view. For the former, we believe that PSTs with higher moral beliefs may not be willing to teach these issues in their classrooms because they do not want students to learn different perspectives about them. For the latter, a moral teaching goal, such as protecting children from the harmful effects of GM foods, might be responsible (Lee &Witz, 2009). In addition, the PSTs who chose Exclusive Neutrality had a lower level of risk perceptions than did those who chose Committed Impartiality. It is possible that a higher risk perception will lead PSTs to incorporate these issues into their teaching. This finding may also be related to a moral teaching goal, such as desire to educate a healthy generation of students (Cross & Price, 1996). However, we do not know whether PSTs with higher risk perceptions will impose their ideas, create a democratic environment or be a model for children.

Table 5. *Pearson Moments Correlations between Effectiveness Beliefs about Teaching Methods and Content Beliefs*

	Knowledge	Moral	Religion	Risk
Conceptual Change text	.112*			.144**
Drama				
Large class discussion				.143**
Role play				.111*
Multiple intelligence				.103*
Inquiry				
Concept Cartoons				.153**
Small group discussion			.111*	
Concept maps				
Computer assisted teaching	.107*			
Using newspapers				.133**
Project based learning	.111*			
Didactic teaching				
Lab activities				.108*
Question-answer sessions	.117*			
Play				
Inviting experts				.135*
Discovery				
Internet research	.109*			
Cooperative learning				
Analogy				
Problem-based learning				
Case				.135*
5E learning cycle				
Outdoor education				.184**

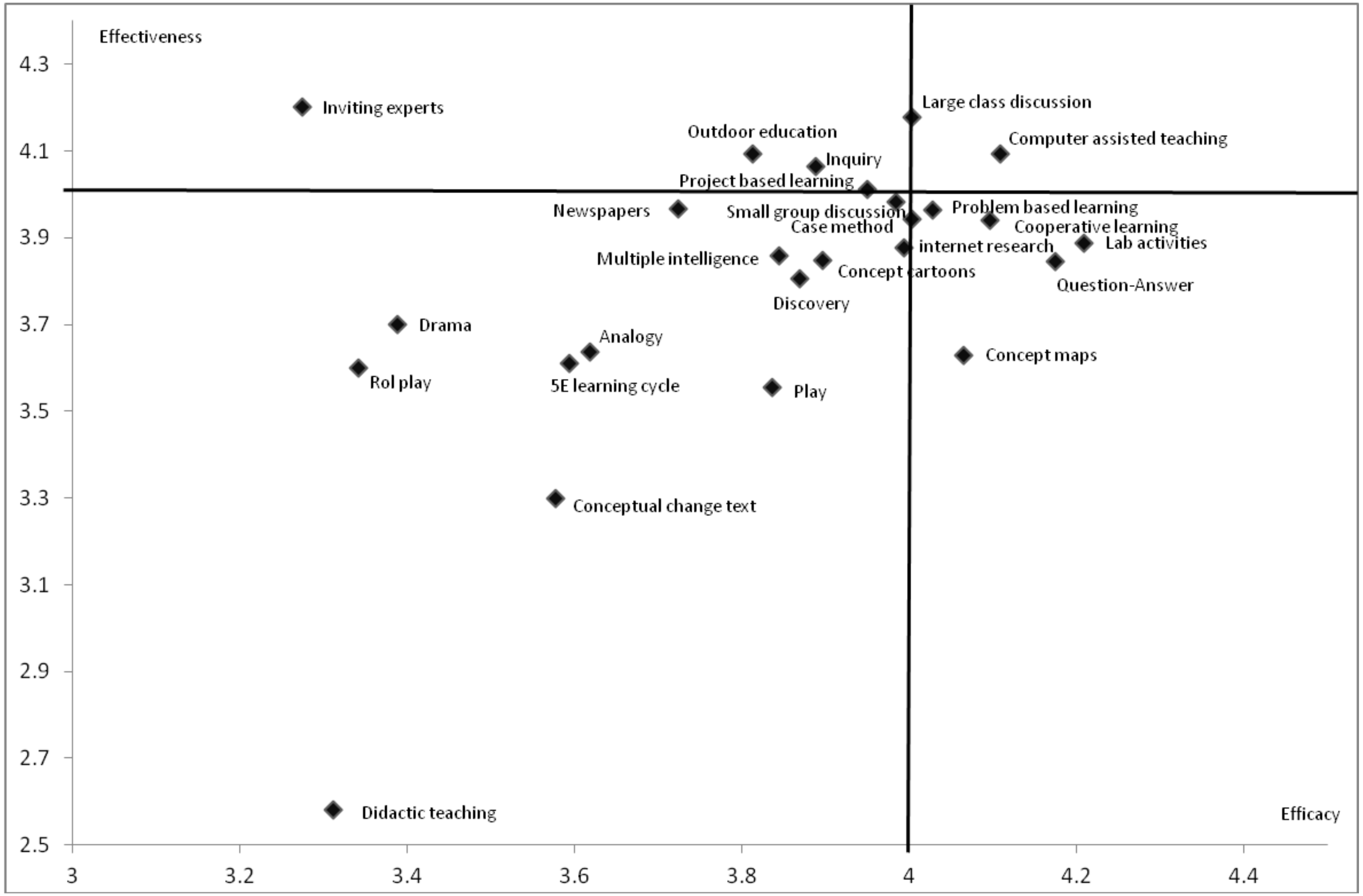

Figure 3. *The Scatter Gram Showing the Potential Use of Teaching Methods in SSI Education*

In terms of teaching methods, PSTs would potentially use computer assisted teaching and large class discussions in SSI-based education in the future. Collaborative and inquiry-based learning environments such as project based learning, cooperative learning, small group discussion, inquiry and problem based learning follow these methods. In addition, they most commonly considered that conceptual change methods would not be very effective in teaching SSI. These results show that PSTs can feel that SSI-based education requires collaborative and interactive classroom environments, where students collaboratively produce knowledge, collect data and make inquires. In addition, they can separate these methods from more classical ones based on teaching conceptions. These positive results are consistent with expectations and suggestions of scholars (e.g., Sadler, 2011a). However, we still believe that these results should be interpreted carefully considering certain opposite results in Turkish literature. For example, computer assisted teaching and large class discussion are frequently used by science teachers and lecturers in Turkey. It seems that the PSTs selected these methods to provide a conceptual background about GM foods for their students because computer assisted teaching in Turkey is a preferred method for particularly conveying new concepts (Yesilyurt, 2011). In addition, large class discussions are a form of recitation, including question-answer-evaluation sessions, in Turkish classrooms (Author, in submission). These findings show that the methods with high potential of use may turn into the environments where students deal with conceptions and try to memorize them.

Another intriguing result was the reluctance of certain PSTs to use role-play and drama in teaching about GM Foods, even though these methods include roles that represent different positions and ideas about SSI cases. Consistent with their responses, we can argue that PSTs lack experience in using these methods in SSI-based education. Lack of expertise is also observed in inviting experts even though this method is considered very effective. This situation may stem from PST's previous schooling and teacher training. Perhaps they had limited mastery and vicarious experiences about these methods. In addition, we found weak correlations between CBs and beliefs about the effectiveness of teaching methods. Considering the correlation coefficients are less than .200, it is not appropriate to make any causal comment. However, we can speculate that PSTs with high risk perceptions tend to use a range of teaching methods or a combination of different teaching methods to convey pessimistic messages to school children.

Finally, based on the above interpretations, we completed our theoretical model in Figure 1 by adding CPBs in Figure 4.

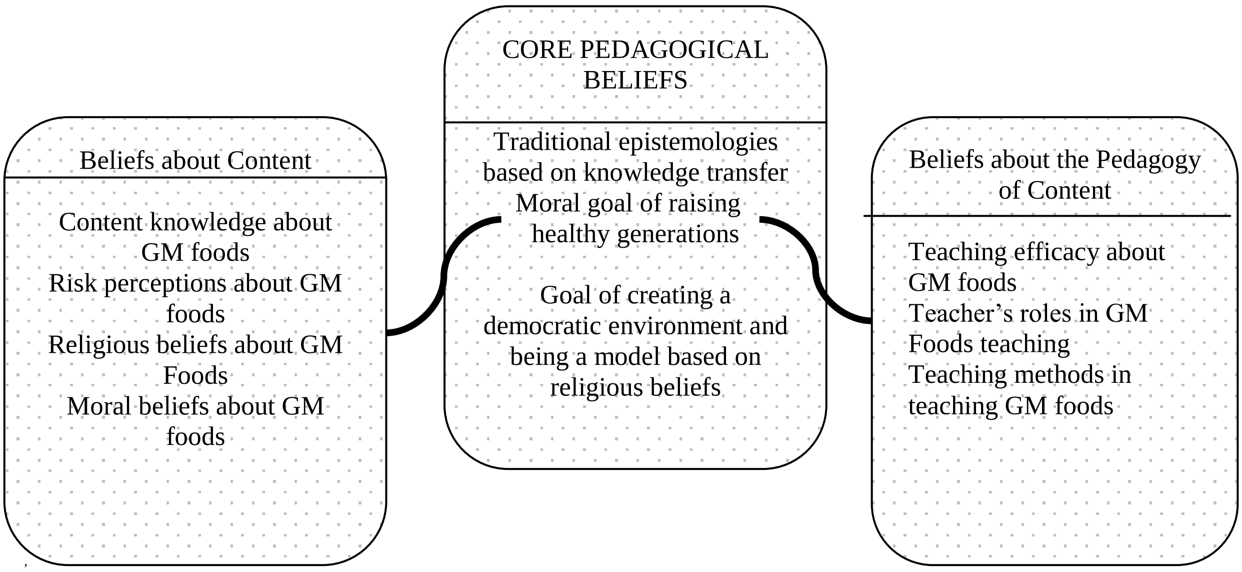

Figure 4. *Final Version of the Belief System for Teaching about GM Foods*

CONCLUSION and IMPLICATIONS

We argue that a belief system about teaching SSI exists and suggest that it includes a nested belief framework including professional beliefs (CPBs and PCBs) and personal beliefs (CBs). PSTs may bring their personal values and beliefs into classrooms and use their core educational beliefs as a filter, and it is possible personal CBs about SSI, reshaped by CPBs, influence PCBs about SSI. For instance, a teacher who is unwilling to cook with GM foods for her children may believe that she should bring her pessimism from home into the classroom. She may have a core educational belief such as raising a healthy future generation, which will lead her to impose her personal beliefs on school children without discussing positive views of GM foods. She may consider that she can teach negative perspectives more efficiently because of her personal beliefs and core educational beliefs. She may not permit exchanges in the classroom and prefer recitation and question-answer sessions that guide students towards her personal truths. Therefore, any suggestions about the implications of this study should not take only individual beliefs into account, but the whole belief system.

Two fundamental implications emerge from our results: Change and New Focus

A) Change

We could easily argue that PSTs are not ready for curricular reform in Turkey. In particular, their PCBs do not generally fit with the expectations of SSI reform. In terms of teaching efficacy beliefs, rather than general science instruction and knowledge transfer, we believe that it is essential to prioritise NOS instruction, the development of moral and ethical reasoning and sophisticated epistemologies. We suggest more (mastery) practices for SSI instruction in Science Teaching Methods courses and teaching practicums in real classrooms so that PSTs can experience inconsistencies between their existing beliefs and intended ones (Posner et al., 1982). In these practices, explicit NOS learning and teaching (Akerson, Abd-El-Khalick, 2000) and the tenets of ethical and moral reasoning (Zeidler& Lewis, 2003) can be emphasised. In addition, incorporating advanced science courses such as 'Specific Issues in Biology' into science teacher education will enhance PSTs' teaching efficacy about SSI because content knowledge is an important predictor of efficacy. Similarly, rather than selecting positions of Exclusive Neutrality and Exclusive Partiality due to moral teaching goals, teachers can select more dialogical roles such as Neutral Impartiality or Commited Impartiality based on mature epistemologies and promising teaching goals such as character development. At this point, the four teacher roles identified by Kelly (1986) can be introduced to PSTs, who should then reflect on these roles. In addition, rather than selecting teaching methods based on traditional goals, such as teaching concepts and transmitting knowledge, teachers should choose methods based on the interplay of different ideas and dialogues between student and teacher and student and student (small group discussion, role-play, drama, etc.). Science teacher educators can highlight that conceptual understanding is only one goal of SSI teaching among a set of cognitive, affective and behavioural outcomes. Methods such as role play and drama can be incorporated into Science Teaching Methods courses by contextualising them within SSI education. In addition, successful examples of inquiry based technology integration in SSI education (see the COREFLECT project: www.coreflect.org) and efficient discussion environments such as deliberative discourse (Michaels, O'Connor &Resnick, 2008) can be introduced to those PSTs who already believe that both these environments are suitable for SSI education.

Apart from content knowledge, we believe that we should not try to change personal (content) beliefs because they are unique to individuals and are shaped by a range of factors, on which pedagogical environments have a limited influence. In addition, certain personal beliefs can make the belief shift easy, as in the case of the effect of religious beliefs on the selection of Committed Impartiality. We suggest that science teacher educators should diagnose these content beliefs before giving instructions about teaching SSI. This diagnostic awareness will provide educators with certain predictions (e.g., PSTs with strong moral beliefs may not want their students to learn different perspectives) and allow them to organise their teaching programmes, modules and materials to these specific groups.

We believe that if educators aim to create a complete shift in PSTs' minds, then change-based strategies should target CPBs (filters) even though these beliefs are the most resistant group to change in the belief system (Ertmer, 2005). However, this change is likely to automatically cause the expected changes in PCBs. Although most core educational beliefs are shaped before entering university, teacher training institutions still have a chance to reshape their student-teachers' beliefs (Pajares, 1992). As scholars (e.g., Pajares, 1992) argue, three steps may be useful: eliciting beliefs, creating inconsistencies and encouraging a willingness to use suggested beliefs. Using questionnaires and/or interviews, science teacher educators can understand PSTs' existing core educational beliefs in first stages of university education. After that, they can plan a purposeful teaching programme in both science and science education courses that takes into account existing core frameworks. As a second step, we believe that PSTs should encounter inconsistencies within their core system and the system we ask them to enact. In our teaching SSI context, PSTs should master mature epistemologies: for example, 'knowledge is uncertain in some cases', and 'truths are true to some extent and according to context'. In addition, the current goals of science teaching should be made explicit in different courses (e.g.,educating scientifically literate people who can make informed decisions, handle uncertainties and build arguments). Lecturers in science and science education courses can continuously use inquiry based, collaborative teaching approaches, support PSTs directly and/or vicariously and adopt dialogical roles in controversial issues. In addition, it should be emphasised that teaching SSI is different from teaching other regular science topics and that, in addition to conceptual learning, it includes collecting and analysing the data, evaluating evidence, coping with uncertainties, defending arguments and increasing moral and ethical sensitivity. If these goals and inconsistencies based on experience and professional support are incorporated into science teacher training, we believe that certain PSTs may be willing to change their core beliefs and produce better ones that fit with suggested SSI teaching.

B) New Focus

One another contribution of this research is its theoretical approach. The study of belief systems, rather than individual beliefs, provides more reliable information about teachers' beliefs (Fives &Buehl, 2012). We suggest that beliefs are complex and interrelated. When we discard a few beliefs from existing belief systems, we may lose sight of important relationships and core factors. For instance, if we had focused on teaching efficacy beliefs without investigating content beliefs, we may have concluded that PSTs have moderately high efficacy beliefs and that this is good news for curricular reforms. However, our finding that risk perception is a predictor of teaching efficacy recalibrated our focus and led us to suggest that (science) teacher education researchers need to do the same. Instead of observing the content of a small cell in a leaf, studying part of the tissue provides additional information about the relationships between the cells and their effects on one another. The present study reconfirmed the importance of the belief system model in SSI teaching, which was suggested in previous works. We consider this model to be useful in understanding teachers' beliefs and reactions to topics in science and other areas.

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APPENDIX

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. 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 prepare scenarios and materials for discussions?
How well can you use different teaching methods in teaching controversial issues, such as GM foods?
How well can you teach your students to reason ethically about genetic modification?
How well can you respond to student questions about GM foods?
How well can you implement the necessary steps to teach ideas about GM foods?
How well can you determine the learning goals for this course?
To what extent can you provide an alternative explanation or example when students are confused?
How well can you help your students to be aware of different opinions and beliefs about GM foods?
To what extent can you develop students' higher order thinking skills during discussions about GM foods?
How well can you hold students' attention during discussions?

Teacher's Roles about GM Foods Education
The roles that science teachers take in teaching GM Foods are given below. Please tick one of these roles that best represents your choice when you become a science teacher.

ROLE 1: The teacher does not introduce controversial issues in the broader community, nor does the teacher share opinions on such topics. Teachers should stick to the value-free teaching of that knowledge and set of skills which have been conclusively demonstrated to be true or important through rigorous scientific investigation or through broad consensus within the community.

ROLE 2: The teacher strives to convince students to adopt a correct and preferable position on controversial issues such as GM foods. Teachers disclose for the purpose of convincing students to accept the teacher's own perspective.

ROLE 3: The teacher promotes classroom discussion and is committed to not explicating his/her position on GM foods, but encourages students to do so. The aim here is not to impose other ideas, rather to show that different ideas, previously overlooked or under-considered in the discussion, would be relevant in making informed decisions about GM foods.

ROLE 4: The teacher promotes classroom discussion and is committed to disclosing his/her opinions on GM Foods and encourages students to do the same. The goal is to model a thinking process not to advocate for an outcome.

Teaching Methods (Efficacy) in SSI Education
Pleaseshow how muchyou can use following each method efficiently when you become a teacher, by choosing one of the numbers in response alternatives.

Teaching Methods (Effectiveness) in GM Foods Education

How much will following teaching methods be effective in a course where concepts, different points of views and decision making skills about GM foods are taught?

Role play
Drama
Large class discussion
Small group discussion
5E learning cycle
Problem based learning
Concept Cartoons
Conceptual Change text
Conceptmaps
Computer assisted teaching
Using news papers
Project based learning
Didactic teaching
Lab activities
Outdoor education
Cooperative learning
Question-answer sessions
Play
Case
Discovery
Internet research
Analogy
Inquiry
Inviting experts
Multiple intelligence