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Research Article

Resistance to Dialogic Discourse in SSI Teaching: The Effects of an Argumentation-Based Workshop, Teaching Practicum, and Induction on a Preservice Science Teacher

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Abstract: Teaching socioscientific issues (SSI) necessitates dialogic discourse activities. However, a majority of science teachers prefer monologic discourse in SSI contexts. In addition, some of these teachers are resistant to change (from monologic to dialogic discourse) despite certain professional development attempts. The purpose of the present single-case study was to investigate the nature of this resistance in a preservice science teacher (PST) (Duygu). We longitudinally followed preservice teachers through 1 year of their continuum of professional development (CPD). We administered a questionnaire including vignettes representing two types of discourse (monologic and dialogic) in SSI teaching; the participants selected one of the vignettes at four different points in their CPD: before an argumentation-based workshop ($N = 122$), after the workshop ($N = 6$), after a SSI-based teaching practicum ($N = 5$), and during the induction year ($N = 1$). The interviews (semi-structured and stimulated recall) and classroom observations supported these data. We concluded that the argumentation-based workshop decreased Duygu's resistance to dialogic discourse by producing pseudo-changes, emergencies, and no changes in her beliefs. However, negative experiences during the teaching practicum enhanced resistance and resulted in a reversal of previous positive beliefs. Similarly, negative induction experiences contributed to her resistance by elaborating previous negative beliefs. In addition, we argue that resistance to change is a complex process exceeding the boundaries of units (e.g., discourse), subjects (e.g., SSI), and subject-matter education (e.g., science education). The cognitive mechanisms (epistemic heuristic, evidence-based justification, and prioritization), belief development processes (pseudo-change, reversal, etc.), and a range of barriers (limited educational opportunities, naïve epistemologies, an argumentation-avoider personality, etc.) produce a complex ecosystem. We believe that any effort that would be conducted to change science teachers' teaching orientations from monologic to more dialogic versions and that does not consider this ecosystem will not thrive. © 2017 Wiley Periodicals, Inc. J Res Sci Teach 954:764–789, 2017

Keywords: resistance to change; socioscientific issues; dialogic discourse; preservice science teachers

Many governments have incorporated socioscientific issues (SSI; e.g., nuclear energy and cloning) into science curricula. The changes in the nature of science and scientific literacy, governmental pressures on the enhancement of the public understanding of science, and promising learning outcomes are influential factors in this incorporation (Sadler, 2011). However,

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recent findings have shown that there is a gap between the expectations of these reforms and classroom practices (Kilinc et al., 2017). This gap is particularly relevant to classroom discourse (McNeill & Knight, 2013). Although teaching SSI requires dialogic discourse activities, such as argumentation and socio-moral discourse, most science teachers prefer monologic discourse (i.e., authoritative talk, Barrue & Albe, 2013). At this point, several researchers have organized continued professional development (CPD)[1] activities to change monologic teachers' belief systems so that they adopt dialogic discourse in SSI teaching. The results of these interventions have shown that certain (preservice and in-service) science teachers resist change (e.g., Wang, 2014). However, these studies have not explained why these teachers are resistant to dialogic discourse and how they have developed such resistance. The purpose of the present study was to understand the nature of resistance to dialogic discourse in SSI teaching in a preservice science teacher (PST) (Duygu) case. This goal is important because unless science teachers' resistance to dialogic discourse is weakened and they continue using monologic orientations, embedding SSI into science education programmes will be highly problematic.

In the following sections, we will first present our theoretical framework based on teacher's beliefs, belief change, and resistance to change. This framework will illuminate our terminologies, methods, analyses, and interpretations. We will then present background information at two levels. We will first explain the nature of classroom discourse in science classrooms and science teachers' resistance to dialogic argumentation in CPD activities. We will then narrow our focus and present previous findings specifically about the nature of SSI discourse and science teachers' resistance to dialogic SSI discourse in CPD activities.

Theoretical Framework

Teachers' Belief Systems, Belief Change, and Resistance to Change

Rokeach (1968) defined belief broadly as "any simple proposition, conscious or unconscious, inferred from what a person says or does" (p. 113). Teachers develop a range of beliefs about the self, knowledge and knowing (epistemology), teaching, and student learning (Fives & Buehl, 2012). These beliefs exist in a belief system that includes many connections among different beliefs (Kilinc et al., 2013). Teachers use these belief systems to make decisions about their teaching practices on a daily basis (Buehl & Beck, 2015).

Because educational reforms are based on new ideals that are not usually a component of teachers' existing belief systems, some changes in the configuration of teachers' beliefs are necessary (Fives & Gill, 2015). When an educational reform is presented to teachers, they first experience a cognitive dissonance or doubt and then make reflections on the gap between their belief systems and the expected changes (Fives, Lacatena, & Gerard, 2015). If the reform expectations are easy to undertake using their existing repertoire of beliefs and knowledge and they are motivated enough, the teachers integrate new beliefs into their existing belief systems (Gregoire, 2003). The position of the beliefs in their belief systems is also important in this integration (Kilinc et al., 2013). Recent research shows that central beliefs, such as epistemologies, are harder to change than peripheral beliefs, such as content beliefs (e.g., Francis, Rapacki, & Eker, 2015). In addition, if reform efforts are compatible particularly with core, central beliefs, their chance to be put into practice enhances (Lee & Witz, 2009).

However, belief change attempts may result in resistance. In teacher education, resistance is used as a term of an individual's agency, that is, "the conscious choice individuals have to act (or not) in response to the difficulties and/or contradictions they encounter as they attempt to reconcile their ideological and pedagogical orientations with the expectations of teacher education programs and the realities of teaching in real schools" (Rodriguez, 2005; p. 9). Consistent with the

aforementioned belief-change conditions, resistance to change may occur either because teachers disagree with a new orientation or because the teachers may lack the awareness, confidence, knowledge, or skills to implement a new idea (Rodriguez, 2005). Some teachers disagree with a new idea because they experience conflicts between their core educational beliefs and proposed orientations, fail to recognize the need for change because of teaching habits, sense threats to their expertise and power relationships, and fear the disruption of the security of following well-established professional patterns (Zimmerman, 2006). In the case of teachers who lack the awareness, confidence, knowledge, or skills, even though their central beliefs may be compatible with reform efforts, they do not have sufficient educational opportunities to efficiently enact these beliefs in real classrooms (Borko, 2004). In addition, their sociocultural contexts, including colleagues, administrators, students, and infrastructures, are not usually supportive for the intended change (Price, 2012).

Background Information

Classroom Discourse, Science Teachers, and Resistance to Change

Classroom discourse is an important component of recent reform efforts in science education (McNeill & Knight, 2013). These reform efforts are influenced by Bakhtin's (2010) and Vygotsky's (1968) perspectives. Bakhtin (2010) believed that there were two types of discourse: monologic and dialogic. In monologic discourse, inflexible channels are used. The messages are compact and indivisible. In dialogic discourse, on the contrary, there is a reciprocal tradeoff of history, culture, and experience between the sides. With a more pedagogical orientation, Vygotsky (1968) argued that students contribute to another's thinking, find opportunities to evaluate meanings, and enter a collaborative meaning-making process through dialogic talk in their zones of proximal development.

Consistent with these approaches, "learning science as argument" has become the slogan of recent discourse-based science education reforms. Martin (2010) argued that science was not an unproblematic collection of facts about the world. There have been controversies between scientists about puzzling scientific evidence. Therefore, practices, such as assessing alternatives, weighing evidence, and evaluating the potential viability of scientific claims, have been seen as essential components of scientific arguments. In addition, Kuhn (2010) noted that argumentation was at the heart of science and was the main way of producing scientific knowledge. To achieve the goal of learning science as argument, teachers therefore encourage their students to collect scientific evidence, collaboratively reason the evidence, justify their claims with reasoning and evidence, and discuss their arguments with their counterparts.

Although learning science as argument necessitates dialogic discourse environments, most science teachers prefer monologic discourse in their science teaching. They usually benefit from question-answer-evaluation (QAE) sessions that do not permit argumentative virtues or student–student interaction (Scott, Mortimer, & Aguiar, 2006). In these sessions, the teacher asks questions, the students answer them, and the teacher then evaluates the answers in terms of their correctness according to the scientific knowledge described in the curriculum (McNeill & Pimentel, 2010). Some scholars have argued that pedagogical limitations may be responsible for monologic science teaching. Zohar (2007), for example, noted that PSTs were incapable of constructing arguments and counterarguments. They had little knowledge about argumentation strategies and were unable to recognize evidence. Teachers' central pedagogical beliefs were one another reason for using monologic science teaching. Wang (2014), for example, identified that argumentation did not match with some science teachers' teacher-centered teaching beliefs and that they therefore did not become interested in argumentation. Some factors that are

related to students are also responsible for monologic orientations. Newton, Driver and Osborne (1999), for example, concluded that management problems in classroom discussions and children's traditional views of learning were responsible for science teachers' limited use of argumentation.

These negative results imply that there is a gap between the existing belief systems of science teachers and the expectations of the educational ideal, that is, learning science as argument. Therefore, certain scholars organized CPD activities to change current science teachers' discourse orientations from monologic to dialogic. Martin and Hand (2009), for example, organized a single case study with a science teacher after a CPD program. They recorded 13 courses over 2 years. In the first stage (first five courses), the teacher focused on content, did not permit student–student interaction, and frequently used QAE sessions. On the contrary, in the second stage (remaining courses), the teacher enhanced student participation, used the terms of evidence and claims, and asked deep questions. The authors concluded that the shift from monologic to dialogic orientation was challenging and took a long time. In another study, Simon, Erduran, and Osborne (2006) organized CPD activities for 12 volunteer science teachers. These teachers participated in workshops to learn how to design teaching materials and use argumentation strategies. In the first workshop, the teachers had concerns about presenting alternative scientific theories to students because they worried they might confuse the students and enhance their misconceptions. However, at the end of the year, these concerns had diminished. The teachers encouraged students to listen to each other and justify their claims by evidence. However, two teachers displayed resistance to change. The researchers argued that although these teachers had an awareness of the goals of argumentation, their initial understanding of argumentation determined their CPD. In another study, McNeill and Knight (2013) organized three workshops with the participation of science teachers. After the workshops, they noticed that the teachers had struggled to understand students' evidence-based reasoning and to ask questions to initiate argumentation sessions. The teachers did not develop any understanding of how to evaluate classroom argumentation, though they were successful in evaluating the written arguments. They also had concerns about students' misbehaviors during the discussions. In addition, the researchers noticed that some teachers continued using QAE sessions in their classrooms despite the CPD activities.

SSI Discourse, Science Teachers, and Resistance to Change

Nuclear plants, GM foods, and cloning are examples of SSI. These issues are controversial by nature and do not include clear-cut solutions (Sadler, 2011). Many governments have incorporated these issues into science education curricula for three reasons: (i) changing the nature of science and of scientific literacy; (2) Enhancing the public understanding of science; and (iii) promising learning outcomes. Regarding the first, current scientists try not only to develop a fundamental understanding of natural phenomena but also to collaboratively study with engineers to produce biotic or abiotic tools for public use. In other words, current science operates in a manner in which social interactions play a central role (Cavagnetto, 2010). This change in the nature of science has influenced how science should be taught. Scholars (e.g., Roberts, 2007) have therefore argued that science education should aim at reaching citizens who can understand the relationships among science, technology, and society in order to make informed decisions rather than focusing on pre-professional training. The second reason for SSI incorporation is governmental pressures on the enhancement of the public understanding of science. Recent examples of badly managed SSI, such as swine flu and the Fukushima disaster, resulted in huge economic losses (e.g., anti-vaccine campaigns against swine flu and closing nuclear plants in many countries). Scholars believe that these governmental investments did not take public input into account and that the public used its

risk perceptions based on dread and uncertainty in making decisions on these issues (Halverson, Siegel, & Freyermuth, 2010). Therefore, the European Union, for example, advised incorporating SSI into curricula to produce generations of people who can discuss these issues and fairly evaluate the evidence (European Union, 2012). The last reason for incorporating SSI into curricula is promising learning outcomes of SSI-based education. Recent research shows that teaching SSI produces strong learning outcomes, such as advanced content knowledge, sophisticated epistemologies, informed decision making, moral sensitivity, and higher-order thinking skills (Zeidler & Kahn, 2014).

Scholars (e.g., Zeidler & Nichols, 2009) have suggested dialogic discourse activities such as argumentation, debate, discussion, critical thinking, and socio-moral discourse for SSI-based education, considering their controversial nature and expectations of fair evidence evaluation. They also believe that SSI discourse is different from scientific discourse because it covers value-laden, moral, ethical, political, and decision-making issues apart from scientific argumentation and because it does not result in clear ends (Wang, 2014). In good practices of dialogic SSI discourse, students use informal reasoning patterns, negotiate competing scientific claims, jointly construct shared social knowledge, and develop moral and epistemic operations (Sadler, 2011). In addition, in these environments, science teachers are experts on the subject matter, pedagogical content knowledge, interpersonal relations, and moral reasoning (Venville & Dawson, 2010). They also respect students' ideas, produce a safe environment for discussions, bring different stakeholders' ideas into the classroom, ascribe importance to dialogs, and encourage students to present their arguments including claims and evidence (Presley et al., 2013).

Although SSI-based education requires dialogic discourse activities, as in the reform of learning science as argument, most science teachers prefer monologic discourse in teaching SSI. They adopt monologic discourse either by adhering to the facts without discussing value-based aspects or by simply lecturing on the pros and cons (Oulton, Day, Dillon, & Grace, 2004). Aikenhead (2006) called these teachers pipeline enthusiasts. Such teachers possess an orientation that engenders the transmission of scientific knowledge and techniques in a canonical sense to persuade students of the correctness of a scientific worldview enhanced by positivism and realism. In a recent work, Kilinc et al. (2017) investigated the causal patterns of PSTs' selection of monologic or dialogic SSI discourse. They found that problematic epistemologies (e.g., seeing legitimate science as value free and embodying the proper authority of teachers) and teaching goals (e.g., protecting children from harmful foods) were responsible for the selection of monologic SSI discourse. Notably, some of these problematic structures (e.g., reaching absolute truths and correcting students' ideas) were also influential in the selection of dialogic versions. In addition, certain scholars believe that pedagogical limitations might be responsible for the use of monologic orientations in SSI teaching. Kolsto et al. (2006), for example, noted that some PSTs evaluated evidence of SSI superficially and used a low number of criteria to evaluate the evidence. The management of uncertainty and controversies, inadequate background knowledge and experiences, fear of losing control over the class, time limitations, the length of curricula, national examinations, a lack of support from colleagues, administration and parents, and communication barriers with students are the other factors leading science teachers to adopt more monologic orientations in SSI teaching (Aikenhead, 2006; Barrue & Albe, 2013).

These negative results show that there is a gap between the expectations of SSI-based reform attempts and existing belief systems of science teachers (Day & Bryce, 2011). Scholars have therefore organized CPD activities to bridge this gap. Venville and Dawson (2010), for example, argued that a brief CPD was sufficient for an experienced biology teacher to develop his skills to

successfully introduce socioscientific argumentation. He used whole-class discussion and individual writing frames. At the end of these activities, students' argumentation quality was enhanced. However, the researchers noted that this biology teacher was one exemplary teacher. In another study, Sadler (2006) focused on argumentation and its pedagogy in SSI contexts in a PST group. As an instructor, he presented argumentation and instructional themes for using argumentation in school contexts in a science teaching methods course. In addition, he asked preservice teachers to incorporate argumentation-based instruction in state schools. At the end of the study, he concluded that most participants considered argumentation to be a pedagogical strategy useful in teaching scientific concepts rather than an important goal of science education. Although the majority attempted to incorporate argumentation into their student teaching, some participants did not use discourse or argumentation. The primary reasons included classroom management, the difficulty of incorporating inquiry, the busy schedule of the teachers, and the complexities of adolescent students. In addition, preservice teachers said that they did not observe argumentation sessions in state schools. In another study, Gray and Bryce (2006) organized a week-long biotechnology summer school to enhance biology teachers' practical knowledge and skills about biotechnology. After the summer school, teachers were extremely positive about the contents. However, because they believed that science is a factual, objective, and positive discipline, they had uncertainties and limited confidence when it came to confronting unfamiliar "nonscientific" aspects of new biotechnologies. They had concerns regarding the time for course coverage, formal examination requirements, and uncertainties about teaching approaches for SSI teaching. Because of these obstacles, they continued to adopt traditional approaches to teaching (monologic teaching). Finally, Ekborg, Ottander, Silfver, and Simon (2013) investigated science teachers' experience of working with SSI. The teachers chose one SSI case and were free to organize the work as they found appropriate. Before this activity, the researchers organized a 1.5-hour whole-group meeting in which they explained SSI, how SSI can help school science and the teaching frameworks. The results showed that the teachers were willing to use SSI cases and included elements of SSI but mostly introduced the regular science content.

Summary, Purpose, and Research Questions

Given the theoretical framework and literature review, it is clear that some teachers develop resistance to change when they experience an educational reform either because of pedagogical limitations or because of inconsistencies between their belief systems and expectations of reform attempts. This resistance is experienced in the science teacher community, particularly in the case of discourse-based reforms. Although scholars emphasize the importance of dialogic discourse, most science teachers prefer monologic orientations in teaching scientific and socioscientific topics. Science education researchers have therefore organized CPD activities to change these tendencies. Although some of these attempts have resulted in expected changes, most studies have emphasized that a portion of teachers exhibit resistance to change. However, researchers have not explained the development processes and causal mechanisms of resistance, with the exception of certain interpretations. In addition, it is clear that resistance to change is a complex phenomenon and that research is limited regarding teachers' resistance to discourse-based reforms in science education (Rodriguez, 2005). Bridging these gaps is crucial to the future of SSI teaching considering that many countries have incorporated these issues into their curricula in the last decade and that many science teachers nevertheless organize monologic discourse activities in science and socioscience contexts. Therefore, the purpose of the present research was to investigate the nature of resistance against dialogic discourse in SSI teaching by investigating a PST case (Duygu).

Consistent with our single-case study design (Yin, 2013), the following research questions were designed to achieve this purpose:

- Research question 1. How does a PST develop resistance to dialogic discourse in SSI teaching?
- Research question 2. Why does a PST develop resistance to dialogic discourse in SSI teaching?

Methods

The present research was a longitudinal single case study. A case study was preferred for two primary reasons: (i) we focused on the nature of resistance in a PST, using "how" and "why" questions, and (ii) our purpose was to investigate a real phenomenon (resistance to change) within a real-life context (Creswell, 2012). Our unit of analysis (Yin, 2013) was the resistance to dialogic socioscientific discourse. In addition, we organized a single case design because our case was critical to our theoretical perspectives about resistance to dialogic socioscientific discourse. We selected this single case to determine whether existing theoretical explanations are correct or whether some alternative propositions might be more relevant. In this manner, we believe that our single case can represent a significant contribution to existing knowledge by confirming, challenging, and extending the theory (Yin, 2013).

Context

We studied in a Turkish context. Like many countries, Turkey experiences discourse-based reforms in science education. As a component of a recent update (2013), curriculum developers incorporated argumentation and SSI into school science programs because of the trends in other countries and because of poor PISA results. The argumentative nature of science was emphasized in the 2013 revision for the first time. In addition, the development of scientific habits of mind using SSI was one of 12 fundamental goals of this reform (Ministry of National Education [MNE], 2013).

We investigated our unit of analysis during a period in CPD of a single Turkish PST case. We focused on 1 year of the CPD of this PST in the present study. This specific period (final semester of initial teacher education [ITE] and the first semester of induction) included three important manipulatives: an argumentation-based workshop, the teaching practicum, and induction. In final semester of ITE, we organized an argumentation-based workshop and asked PSTs to organize SSI courses in real classrooms during their teaching practicum. In first semester of induction, we investigated the impacts of the factors that are specific to the induction year. Because preservice teachers produce a range of beliefs based on ITE courses (Fives & Buehl, 2012) and test those beliefs during the teaching practicum (Nettle, 1998) and induction year (Luft et al., 2011), we considered that this period would provide an excellent laboratory environment in which to observe the development of resistance to dialogic socioscientific discourse.

Data Collection and Selection of the Cases

To understand our unit of analysis, we selected one case (Duygu) who was resistant to change. Figure 1 shows the selection of this case and the data collection processes. In addition, Supplementary Material 1 includes the semi-structured interview forms that we used during these processes.

First, we developed the SSI-Discourse Types Questionnaire (SSI-DTQ) that included vignettes representing monologic and dialogic SSI discourses (presented in Supplementary

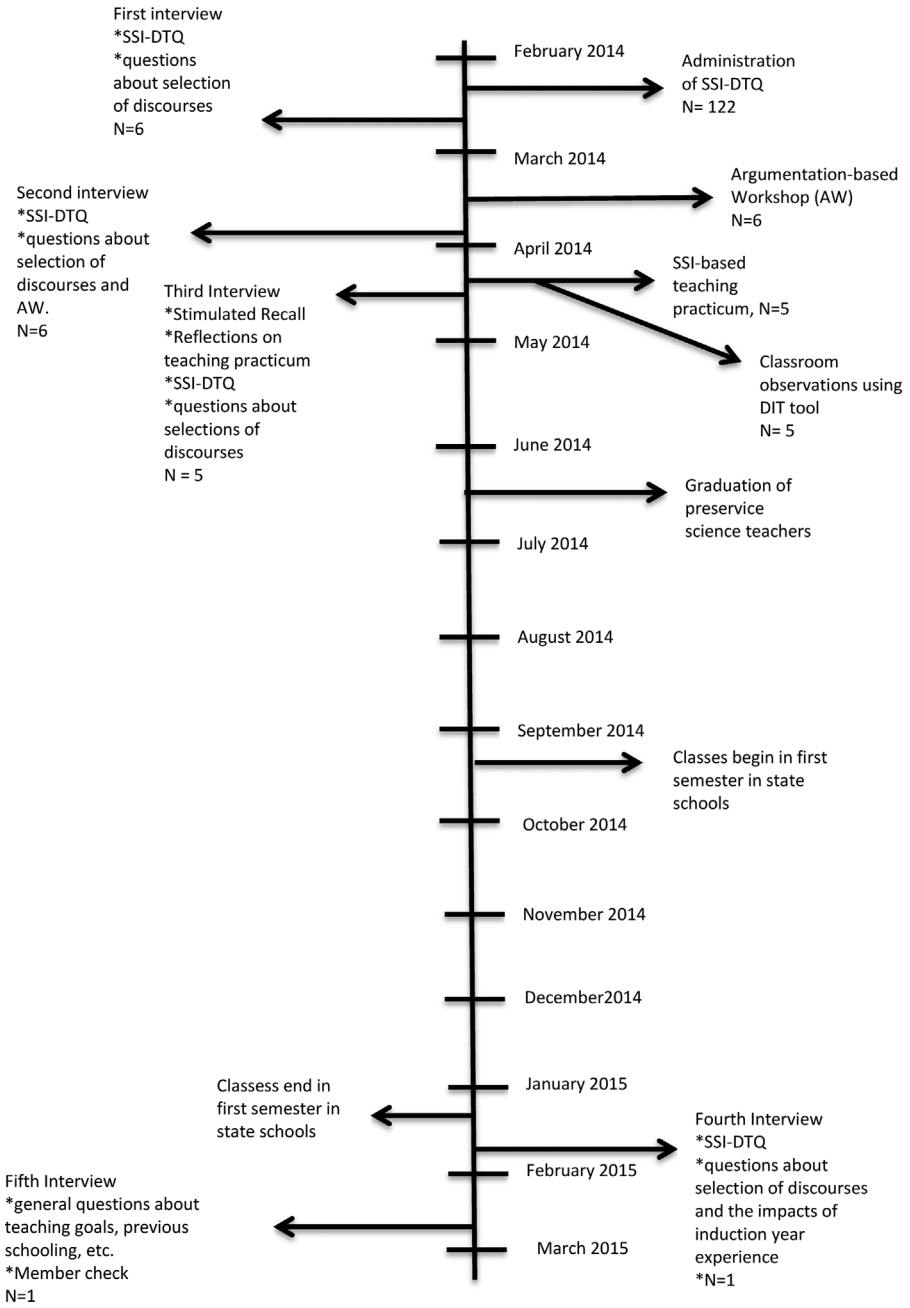

Figure 1. The process of data collection.

Material 2). We produced these vignettes using the common beliefs and behaviors of teachers in two different discourse types in previous studies (e.g., Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006). A group of researchers including three professors of science education, two professors of Turkish language education, and a professor who is expert on questionnaire

development and statistics scrutinized SSI-DTQ in terms of content and language. This group conducted minor language-based changes in SSI-DTQ. We administered the SSI-DTQ to 122 PSTs (27% males, 73% females) during final year of their teacher education in a Turkish university using convenience sampling procedures. In this sample, 13 (11%) participants selected monologic SSI discourse and 107 participants (87%) chose dialogic SSI discourse. In addition, two (2%) participants did not select either role.

We then randomly selected six participants (of 13) who chose monologic SSI discourse. Our preliminary goal was to follow these participants during three critical periods of their CPDs to identify different patterns of belief changes (from monologic discourse to dialogic discourse or the reverse) over the course of nearly 1 year. During this stage, we conducted our first semi-structured interview during which we again presented the SSI-DTQ to the participants to reselect discourse types. All participants selected identical discourse types. This time, we asked the participants to explain their selection.

After that, to change the beliefs of the six selected PSTs from monologic to dialogic socioscientific discourse, the second author offered participants an argumentation-based workshop (AW) over eight course hours on two weekend days (four hours on Saturday and four hours on Sunday). The workshop included two sections (theoretical and practical) and was prepared using the frameworks and materials developed in previous studies (Please see Supplementary Material 3 for the details). In addition, the entire process of the AW was video-recorded. Following the AW, we conducted second interviews with the participants during which we again asked each participant to choose one of the SSI discourse types on the SSI-DTQ and produce justifications. We also asked specific questions regarding how they evaluated the AW and whether the workshop influenced their decision on the questionnaire.

We then invited participants to plan and organize an SSI-discourse lesson in a real classroom as a component of their teaching practicum in a state school. One of the participants was not willing to organize such a lesson for personal reasons and was thus excluded from the study. Two authors were available during the lessons to conduct the observations using Reznitskaya's (2012) Dialogic Inquiry Tool (DIT) (please see Supplementary Material 4). The DIT is an anchored classroom observation scale that is specifically designed to help elementary school teachers examine the quality of talk and discourse during literature discussions. We used DIT because science education scholars (Osborne et al., 2016) suggested that it might better assess the quality of classroom discourse in compare to existing several tools for analyzing scientific discourse and because SSI discourse not only covers scientific dimensions but also includes a range of social aspects. The DIT scale comprises six indicators: authority (teachers' control over discussion processes), questions (the targets and the types of questions), feedback (inspiration for further exploration), meta-level reflection: connecting ideas (relating students' answers to one another), explanation (inviting students to explain their thinking), and collaboration (co-construction of ideas). The observers used the ratings 1 through 6 for each indicator. Ratings 1 and 2 represented monologic discourse, whereas 5 and 6 represented dialogical discourse. In addition, the lessons were video-recorded for follow-up Stimulated Recall (SR) interviews. After this practicum, we conducted a third interview with each participant. The second author first asked the participant to the nature of teaching and learning in the teaching practicum school. The author then asked the participant to explain his/her lesson plan before the practicum. The author and the participant then watched the participant's video that was recorded during his/her practicum. After that, the second author asked what problems the participant had encountered, the stages the participant successfully conducted, and the changes that the participant had made in his/her preliminary lesson plan. At the end, the author asked each participant to choose one of the SSI discourse types in the SSI-DTQ and provide justifications.

In next stage, the goal was to understand the effects of induction year experiences on participants' beliefs regarding SSI discourse. Although all participants ($N = 5$) completed the Examination of Becoming a Teacher in State Schools (EBTSS), only one of the participants (Duygu) was appointed by the MNE. Therefore, we revised our research goal from investigating belief changes from monologic to dialogic SSI discourse or the reverse to scrutinizing the resistance to dialogic SSI discourse because Duygu displayed increasing resistance throughout her CPD. The second author conducted fourth and fifth interviews (by telephone) with Duygu. At this stage, Duygu had completed the first semester of her induction year in a state school. During the fourth interview, the author asked Duygu to reselect one of the SSI discourse types and justify her selection. He also asked specific questions regarding the effects of induction year experiences on her beliefs regarding SSI discourse. The second author conducted the fifth interview (personal aspects) after the analysis of all available data. The content of this interview was shaped by the results of this analysis. Based on the emergent themes and preliminary results, the author asked further questions regarding interest in science, teaching goals, previous schooling, social life, and previous experience with school discourse to better understand the case and support the qualitative results. The author also conducted a member check stage at the end of the fifth interview.

Data Analysis and Interpretation

We benefited from six stages of data analysis and interpretation: preparation, belief selection, time-series pattern matching, thematic analysis, inductive spirals, and causal models. We used the first four stages for our first research question (how). Except for time-series pattern matching, we used the other stages for our second question (why). Three authors independently analyzed the data and met following each stage. In these meetings, each author explained his codes, interpretations, and memos. The discussions included similarities and differences. We did not move to the following stage until 100% consistency was reached.

During the *preparation* stage, we transcribed interviews and classroom observations. We first read all of the transcripts twice, adhering to the longitudinal periods of the CPD. We then wrote memos to create connections among raw data, possible categories, and themes (Charmaz, 2014). In *belief selection* stage, because the present study focused on investigating belief systems regarding resistance to change, we selected beliefs using open codes (Corbin & Strauss, 2014) representing each periods of the CPD. During this stage, we disaggregated, scrutinized, compared, and categorized the sentences and utterances.

For *time-series pattern matching*, we matched the selected beliefs from each stage to produce time-series patterns (Yin, 2013). For each match in different periods of the CPD, we examined the similarities between pre- and post-beliefs more closely. To interpret the belief changes over the time-series, we benefited from Cabaroglu and Roberts's (2000) classifications. Because resistance to change is a complex process, rather than adopting a "belief change" approach, we benefited from a "belief development" perspective. Cabaroglu and Roberts (2000) specified that standard measurements focus on dramatic changes but miss important belief movements (or developments) that exert enormous influence on pedagogical practices. These authors' system covers 11 belief development categories: awareness (awareness of discrepancy or coherence), confirmation (strengthening of existing beliefs), elaboration (deepening of beliefs by additional dimensions), addition (integration of new beliefs), re-ordering (rearrangement of beliefs regarding their importance), re-labeling (re-naming of a construct), linking up (establishing a connection between constructs), disagreement (rejection of existing beliefs), reversal (adoption of beliefs opposite to previous view), pseudo-change (pretended or false change in beliefs), and no change (no apparent change in beliefs).

During *thematic analysis*, we used axial codes (Corbin & Strauss, 2014) to create connections between longitudinal belief patterns. We linked each pattern to the contexts and general

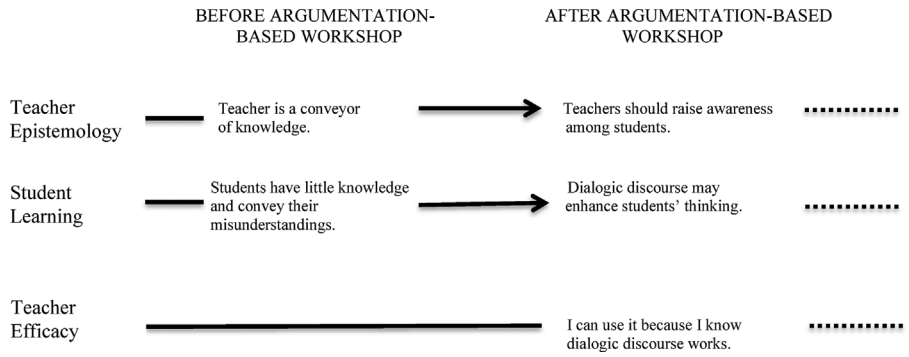

Figure 2. An example representation of selected beliefs, time series, and the themes.

understandings regarding learning and teaching. Figure 2 presents an example representation of selected beliefs, time series, and the themes.

To respond to the "why" question, in addition to previous stages, we created *inductive spirals* that were similar to Creswell's (2012) data spiral. In producing these spirals, we revisited all of the data, the themes, and belief patterns. For each belief development process, we asked the "why" question and attempted to identify reasons in the interviews and observations. In addition, when we developed restricted interpretations, we prepared further questions to ask Duygu in the final interview (personal aspects). Combining the results of the final (fifth) interview and selectively coded the reasons behind each belief development process, we developed core reasons behind the belief development process (Corbin & Strauss, 2014). We then produced *causal (logical) models* (Yin, 2013) that these core reasons to identify clear answers to our "why" question.

Trustworthiness

Trustworthiness is the credibility of results from qualitative studies. For enhancing trustworthiness of the present study (Creswell, 2012; Lincoln & Guba, 1985), we conducted *prolonged engagement in the field*. Duygu was a student of all of the authors (three science educators). The second author was also the consultant research assistant who addressed all official and personal issues regarding Duygu's classroom. Duygu had good relationships with the authors. This background was an important component of building trust with Duygu. In addition, *triangulation of the data* was important to us. We used different types of data sources such as questionnaires, face-to-face interviews, SR interviews, telephone interviews, and classroom observations. One another aspect for producing trustworthiness was *peer review.* We (three authors) planned and organized all stages of the present study. Particularly in data analysis, we independently investigated the data and conducted iterative procedures. In addition, we conducted a *member checking* stage. In the final (fifth) interview, we explicitly questioned Duygu regarding the primary themes, belief patterns, and core reasons behind her resistance to allow her to further clarify and refine our analysis results.

Results

The Case of Duygu

Personal Experience. Duygu was 23-year old at the end of our data collection period. She was the child of a retired father and a housewife mother. Her GPA was 2.60 (of 4.00).

Duygu did not consider herself a sociable person at the university. However, Duygu said that she had good relationships with her housemates. Requested to further expound on university life, she said, *I have a silent character in the classroom. Indeed I am a silent person in my life. The (university) classroom was already a very crowded place; perhaps I could not find opportunities to express myself except for certain presentations or group studies . . . I did not join any social activities.* When we asked whether she was willing to participate in the classroom discussions, she said, *I like being the listener much more than the teller. I make observations and listen. Without taking the issues to the discussion stage, I envisage the issues and try to solve them on my own.*

Regarding the goals of education, she said that education should first educate people and become useful for them. She said that education should produce changes in humans. She said, *It should change the individual. . . it should take people one step or two steps further.* In addition, she believed that science teaching should improve people so that they benefit from nature and the tools consciously.

Regarding the nature of the discourse activities throughout her education (from primary school through the end of university), Duygu said that she commonly encountered teacher-centered learning environments. Duygu recalled, *The teachers have always given and we have always taken. As such, we did not make anything new.* Asked the reason for this experience, Duygu responded, *Because it was easy for the teachers.* She could not remember discourse activities in primary school. Duygu said that the teachers in middle and high school preferred didactic teaching without any activities. She said, *It was very boring . . . always direct teaching!* [There was] *no activity; teachers directly told and moved to another topic.* Her area of study in high school was also a reason: *Because I studied science and mathematics, we always dealt with numbers. There was no any discussion environment.* During her teacher education, Duygu specified that there were certain discussion environments in the courses Educational Sciences and Science Teaching Methods. However, the quality of the discussion was limited because there were only a few exchanges between the presenter PST and the listeners. Duygu also said that she was not willing to participate in these discussions. Asked the reason for her reluctance, Duygu responded, *There were already many joining the discussion. My participation was unnecessary. This was the first reason. Second, the time was limited. The discussion always occurred among three to five persons. The whole classroom did not join any discussion.* When we asked whether she tried to participate in the discussion at any time, Duygu said, *Even if I wanted to join, they were very persistent in talking. We avoided saying anything. It was the mood like "they already do it; it is unnecessary to interrupt.*"

Argumentation-Based Workshop. While the lecturer presented the theoretical nature of discourse and SSI, Duygu, like her counterparts, passively listened to the lecturer. After the lecturer distributed the factory scenarios (Please see Supplementary Material 3) and asked the participants to create "yes" and "no" groups, Duygu placed herself in the "no" group. When the lecturer asked Duygu's opinions, she said, *I guess, I do not want them to build it. Natural life will disappear. On the other hand, people are hungry! I do not know; my mind is a little confused.* This uncertainty was also observed during face-to-face discussions. She preferred remaining silent and did not defend her ideas or rebut others' ideas. She only spoke when the lecturer called on her.

Teaching Practicum. Duygu's practicum school was in the center of Kirsehir. When we asked her opinions regarding the social environment, Duygu responded that the socio-economic background of the students was poor and that anybody could see the poverty by the students' clothes. However, Duygu said that students were interested in the lessons. Duygu characterized the teachers and the principal as warm and helpful people. Duygu said, *They tried to do as much as*

they could. They responded to everything that we asked; they tried to do their best. Regarding her cooperative science teacher, Duygu said, *She was also okay. But, she did not use the white board at any time*. Asked what the teacher did instead, Duygu said *The teacher made the students read from the textbooks and asked them to underline important places. There was no use of notebook or whiteboards. This is a problem, I think. The children do not see anything. It was like a Turkish language course; they always read and passed.*

We asked Duygu to organize a SSI discourse lesson during her teaching practicum. Duygu organized her discourse lesson in a Grade 5 classroom comprising 36 students (24 females, 12 males). She chose the establishment of a lignite coal mine as a SSI topic. At the beginning of the lesson, she explained the details of the coal and the coal sector. She asked certain questions to reveal students' preconceptions. After this stage, she distributed a scenario that she had previously designed. This scenario included the opinions of three stakeholders (owner of the mine company [positive position], a member of environmental protection club [negative position], and a citizen [positive position]) regarding building a lignite coal mine. She gave one copy to five or six students. Her goal was to initiate a small-group discussion before the argumentation session. After this stage, she asked volunteer students to explain their arguments without permitting student–student interaction. She then asked students to form groups representing their positions. Two groups emerged: students who supported the establishment of the mine and students who were opposed. Duygu asked the groups to sit on opposite sides of the classroom.

We evaluated Duygu's lesson using the DIT scale. Her average DIT score was 1.75 (monologic discourse). Regarding *teacher authority,* Duygu was willing to assume a balanced perspective during the argumentation. She said, *I did not intervene . . . because I considered that they could find better methods and ideas by discussing.* Consistent with this stance, she only called on volunteers to explain their arguments. The students sometimes managed their turns, asked questions, and reacted to one another's ideas. However, these positive sentiments were accompanied by many problems stemming from unsuccessful classroom management. At the beginning of the discourse, she invited students to share their ideas by calling on the students who raised their fingers. However, she lost control for a moment, and the students began to converse with one another. Some even spoke loudly and aggressively, leading to increased noise for Duygu to manage. At this stage, Duygu used a range of utterances to quiet the students: *Sshhh! Friends! Please sit down. Be quiet. Why don't you listen to your friend?, etc.* After noting that permitting students to share their ideas without being called on was problematic, Duygu asked volunteers to raise their fingers. However, as the discourse progressed, Duygu called on students but did not communicate with those students. At this stage, Duygu said, *I gave up . . .. As I could not build the authority, something happened to me. My self-confidence decreased.* During the SR interview, she agreed that she could not manage the classroom. The large number of students and Duygu's and her students' limited experience with discussion environments were the primary reasons for this situation. When asked why she did not communicate with students or connect their ideas, Duygu said, *I could not intervene with students because I wanted to stay silent. If I supported one group, the other group might misunderstand. . .* She also suggested that the rules of the discussion should be taught both to students and teachers to avoid similar problems.

Duygu used *questions* at the beginning of the lesson. She considered that she should reveal students' preconceptions and correct wrong ideas to prepare the students for argumentation. She particularly benefited from QAE sessions. Her questions, such as *What is in coal? There is carbon in coal, isn't there?* and *Do you know coal types?* targeted the recall of specific facts. She first listened to the answers and then evaluated the answers by saying *Yes, correct* or by nodding. One moment was particularly important. When explaining the structure of coal, she stressed that coal

comprised plant pieces. One of the students disagreed and said that parts of fossils including both animals (e.g., dinosaurs) and plants were components of coal. Duygu first hesitated to respond; however, after a few seconds, Duygu said coal would be plants, not animals. When acknowledging that the student's response was correct during SR interview, she admitted that she had limited knowledge of the topic.

Duygu rarely used *feedback* during the lesson. She only gave abbreviated feedback such as *Umm* or *OK* that did not invite students to further develop their answers. In SR interview, Duygu explained that she could not give feedback because of the nature of SSI discussions. She believed that when in other types of discussions, teachers gave clear feedback regarding the correctness of students' ideas. However, in SSI discussions, Duygu considered that there was no conclusion to be reached. In addition, Duygu never *connected the students' ideas* before or during argumentation. While presenting the concepts regarding coal, she communicated only with the student whom she had questioned. During the argumentation, she invited volunteers to explain their reasons for their positions. She permitted students to discuss with one another without intervention although this choice caused many students in the classroom to speak loudly with one another. She said, *I guess I lost control due to these face-to-face discussions.*

As for the *explanations*, only a few students in Duygu's classroom presented their positions with one or two justifications. The majority of the students attempted to rebut one another's ideas by focusing primarily on the limitations of others' reasons rather than explaining their own arguments. Duygu did not ask students to explain their ideas; therefore, the responses were brief and factual, comprising only a few phrases. Regarding *collaboration*, perhaps because of the nature of rebutting, students attempted to relate their responses to the other group's arguments. However, students specifically presented their own reasons rather than supporting one another's justifications within the same group. Consistent with this behavior, Duygu generally invited one student from each group to share his/her ideas and then one student from the other group. These zigzag turns did not permit students to collaboratively defend specific claims.

Induction Year Experiences. Duygu was appointed by the MNE to be a science teacher in a state middle school located in a (rural) small town of Antalya. She taught eight classes (four Grade 7 and four Grade 8). She had a busy schedule including 30 classroom hours (40 minutes each) per week. Duygu said that the socioeconomic background of the students was poorer than those in her practicum school and that the discipline in the school was problematic. Duygu said, *There is no respect at first. As such, the respect is at zero level. Am I a teacher or a friend? . . . They do not care. They do not listen to you. Maybe you try to teach something at the simplest level; they do not listen to you. A few even threatened me. There is also a smoking problem in the school.* When asked about the success level of the students, Duygu specified that the principal placed all of the successful students in one classroom; thus, the other classrooms were quite weak. She criticized the principal, saying, *Nobody listens to the principal. So we have to address many problems. The children are not afraid of the principal because he does not apply any discipline-based procedure. They already do not care about the teachers. They sometimes jump on the desks when I turn to the whiteboard.* When we asked whether she used dialogic SSI discourse, Duygu said that she could never use it during induction. Duygu was sure that the other teachers did not use discourse-based teaching. Duygu said, *If you want to talk to the students, the first thing is the respect between the teacher and the student. If there is no such respect, you always try to build the discipline in the classroom in order to make them listen to what you say. This takes a huge amount of time. At the end, you find yourself very tired and you only taught several concepts from the textbooks, not more.* When asked whether she adopted the suggestions of other teachers regarding discourse-based activities, Duygu said that she particularly took suggestions regarding classroom discipline, saying, *We generally*

talk about discipline issues rather than the quality of the lessons. We initiate the conversation by which student has done what today.

Belief Development Processes

In order to understand belief development processes behind Duygu's resistance to dialogic discourse, we used the transcripts of interviews in which we benefited from SSI-DTQ questionnaire probing her preference about SSI discourse types. As shown in Figure 3, we noted that Duygu produced belief patterns regarding three themes: Teacher Epistemology, Student Learning, and Teacher Efficacy. We explain the belief development processes in these themes and use parentheses to show the belief development category representing the change between previous and post beliefs in the following paragraphs.

Teacher Epistemology

Before the AW, Duygu's image of a teacher was of someone strong and authoritative. The teacher should be informative, raise awareness, prefer traditional teaching methods such as question-answer, and not direct students incorrectly. Duygu said, *Teachers do not give wrong information to the students. They note the correct road to the students so they can be good citizens in their future lives. We should inform the students, convey scientific truths and raise awareness among them.* Her pessimism regarding the GM foods also influenced her comments. She said, *I can show the changes in the body after eating GM foods. The students' health is in my responsibility . . . I should emphasize the truths about GM foods*. Although Duygu preferred dialogic SSI discourse after the AW, she maintained her belief regarding the role of the teacher as a knowledge source. Duygu believed that teachers should tell the truth about GM foods so that the students could make informed decisions in their future lives, saying, *These subjects should be presented in the school under the leadership of the teachers. We should make the students conscious consumers* (No Change). She changed her preference from dialogic to monologic SSI discourse after the teaching practicum. We noticed that she nevertheless had similar opinions regarding the teacher as knowledge-giver. Duygu also added that teachers must continuously connect the discussed pieces of knowledge to avoid confusing the students, saying, *I think the topic should be presented by the teachers. The teachers need to connect the components of the topic in different periods of discussion because the students take them through uncertain points* (Elaboration). After her induction experiences, Duygu did not change her preference for monologic SSI discourse. However, she used different terminology for authoritative and knowledge-giver teachers. She said that teachers must use didactic teaching because teachers

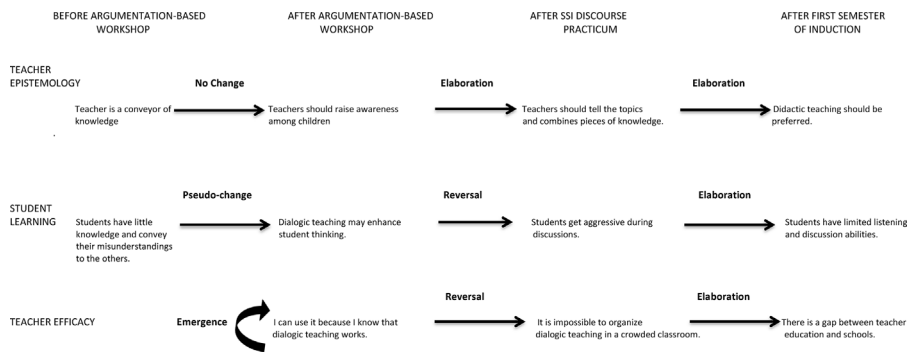

Figure 3. The development of Duygu's beliefs about SSI discourse in the course of time.

must fulfill the requirements of the curriculum in a timely fashion and because of the overcrowding of the classrooms. Duygu said, *I have to use didactic teaching and give tests to the students due to existing conditions such as the high number of students in each classroom and the obligation to complete the curriculum in the time proposed by the MNE* (Elaboration).

Student Learning

Before the AW, Duygu assumed that students had little knowledge of GM foods. Students were not previously interested in conducting research and conveyed their misunderstandings to the other students. Duygu said, *I do not think that students have much knowledge; they do not go for conducting research, so if we leave them to a face-to-face discussion, they would reach meaningless results. If the teachers do not intervene, the students would inject their wrong knowledge into the discussion, and these wrong knowledge components stay in the minds of students.* After the AW, Duygu believed that monologic SSI discourse might not be sufficient to ensure student learning and would not enhance students' thinking abilities. She said, *I chose the monologic one at first, but when we implemented (dialogy) in the workshop, I thought that it was insufficient. In the monologic one, the students' thinking abilities would not develop* (Pseudo-change). However, Duygu immediately changed these positive sentiments after the negative experiences during her teaching practicum. Duygu believed that the students in Grade 5 were not an appropriate group with which to conduct discussions. Duygu said, *These small students understand the components of the discussion incorrectly and become aggressive easily. Additionally, the classroom was too crowded, so I could not maintain discipline. Unless the procedures of argumentation were taught to these students, it should certainly not be tried* (Reversal). After her induction experiences, Duygu elaborated on these negative beliefs. Duygu argued that the school was in a rural area with many crowded classrooms. The students did not listen to the teachers and had certain bad habits such as interrupting their classmates during the discussion. Duygu said, *knowing the rules of discussion? Come on! They are even struggling to listen to each other; they try to speak their ideas without respecting the others' opinions.* Duygu considered the students' poor experiences in prior years to be the reasons for such problems, saying, *I could not succeed with this on my own. There are responsibilities that the other teachers should do too. For example, the culture of discussion needs to be taught even in the primary schools* (Elaboration).

Teacher Efficacy

After the AW, we realized that we must add a new belief development category to Cabaroglu and Roberts's (2000) list. We called this belief development category Emergence. Although Duygu did not mention the efficacy of SSI discourse before the AW, she said that she could implement SSI discourse after the AW. Duygu also commented positively regarding the success of dialogic SSI discourse, considering her experience, saying, *I think I can utilize dialogic SSI. I have seen that it works. The students will enjoy it, like me* (Emergence). After her negative experiences during the teaching practicum, Duygu said that it was impossible to use this method in a crowded classroom, specifying that she was unsuccessful in using dialogy. Duygu said, *I could not be productive and therefore the students could not be successful. I think it is impossible to manage such a crowded classroom. In my lesson plan, I did not expect this classroom. The crowdedness resulted in chaos and noise, caused certain students not to read the scenario and the silent ones to disappear.* Duygu believed that there were many people in her educational background who were responsible for her negative experiences: *I did not have a similar experience in my four-year (teacher) education. I did not see it in my practicum school. Additionally, I did not have any pre-conception about such an environment after the workshop* (Reversal). Duygu produced similar

beliefs after her induction year experiences, maintaining her belief that it was impossible to organize discussion lessons in her school. Although Duygu knew certain constructivist teaching methods, including dialogic discourse techniques, she believed that she did not have opportunities because of time limitations and the high number of students: *It is too hard to conduct discussion due to crowded classrooms. Even if I know constructivist techniques and the discussion, I have to use didactic teaching and solve the test questions because both the lesson duration is limited and the classrooms are crowded.* In addition to these diagnoses, Duygu emphasized the gap between teacher education and the state schools: *There are big differences between teacher education and state schools. I cannot use the knowledge and the abilities that I developed in university in the schools* (Elaboration).

Interpretations and Discussion

How Does Resistance Occur?

Before the AW, Duygu preferred monologic discourse. After the AW, Duygu changed her preference and moved to dialogical discourse. When completing her teaching practicum, Duygu returned to monologic discourse. She maintained that decision after her induction year experiences.

It seems that science teaching courses, such as AW, influence teachers' beliefs in different ways. We noticed that AW was not able to impact beliefs of teacher epistemology (teacher as an authority and as a conveyor of scientific truths) perhaps because these beliefs were core-educational beliefs that were developed through long-term educational life and that were not being able to be influenced via short-time (2 days) interventions (Ekborg et al., 2013; Hofer & Pintrich, 2002). However, these courses may influence teachers' beliefs about student learning. Duygu's case and previous studies (e.g., Simon et al., 2006) confirmed that some (preservice or in-service) science teachers considered that discourse-based activities might not be suitable for school children because they might confuse the students and enhance their misconceptions due to peer interactions. However, after presentation of discourse-based reforms via workshops or teaching methods courses, these concerns could easily be diminished perhaps because of a dual process: evaluations of the activity as a student and follow up estimations as a teacher. For the former, teachers become students in conducting science teaching activities such as the discussion of establishment of factory in our case and they produce new practical evidence for learning-based beliefs. For the latter, they make estimations about possible impact of their teaching on student learning. However, these estimations need to be accompanied by a strong teaching efficacy and a repertoire of teaching knowledge and skills if they would be put into practice. In our case, Duygu considered that dialogic SSI discourse was an efficient way of student learning because she actively used certain thinking abilities as a student and it would work for her students too because she estimated a successful teaching. Therefore, Duygu replaced her beliefs about students' inabilities to discuss with positive beliefs about contribution of dialogic SSI teaching on students' thinking abilities. However, her positive beliefs were not justified by real teaching practices (evidence) and were based only on an estimation. This estimation was also related to Duygu's teaching efficacy. Her teaching efficacy emerged during AW and it was based only on vicarious experience (observing the lecturer and considering to be able to organize the course in a similar way), which is a weaker source of efficacy than the mastery experience (conducting the teaching on her own) (Bandura, 1997).

Duygu enhanced her resistance and used a clear terminology regarding this resistance after her teaching practicum. She reversed her positive beliefs and replaced those beliefs with strong pessimistic beliefs. Her negative evaluations of students' discussion abilities and of classroom

discipline reversed her position. In terms of teaching efficacy, Duygu conducted mastery experience and considered that she could not be productive because it was impossible to organize such discourse with small children. In addition, she elaborated her teacher-centered epistemology and mentioned teachers' authoritative position was necessary for integrating students' arguments. These sentiments showed that Duygu's prior negative beliefs about students' abilities to discuss seem to be justified by real teaching practices (evidence). This evidence-based justification together with mastery experience and elaborated teacher-centered epistemology eased the reversal process. In addition, we can argue that perhaps a science teaching course (e.g., AW) could become a vehicle for promoting discourse-based teaching (Sadler, 2006); however the sustainability of teachers' success is highly dependent on follow-up teaching practices in real classrooms.

On the other hand, we noted that induction year experiences elaborated Duygu's resistance and stabilized her decision to use monologic discourse perhaps because she produced a range of practical evidence. Duygu noted the differences between the contributions of teacher education and the realities of teaching in real classrooms. Many school-based factors such as the socio-economic background of the students and discipline-based problems also came into play. Perhaps induction was the most complex context for Duygu compared with the AW and the teaching practicum because she was required to address a range of issues such as completing the curriculum within the proper time frame as proposed by the MNE, solving test questions for national examinations and classroom management. These responsibilities are also addressed by many science teachers as the barriers before discourse-based activities in science (Newton, Driver, & Osborne, 1999) and socioscience contexts (Aikenhead, 2006; Barrue & Albe, 2013; Gray & Bryce, 2006; Sadler, 2006). These extra burdens appeared to preoccupy Duygu much more than new orientations such as dialogic discourse. In other words, Duygu prioritized the regular responsibilities over expectations of reform-based activities. This order appears to be the primary reason for the enhancement of resistance during her induction period.

These results and interpretations show that teachers' resistance to change is a complex process and cannot be explained only by the inconsistencies between core beliefs and reform expectations. First, it seems that Duygu did not simply develop beliefs about the content suggested by reform efforts. Rather, she contextualized these reform-based peripheral beliefs on some core educational beliefs (Francis et al., 2015; Kilinc et al., 2013) such as beliefs about teacher epistemology, beliefs about student learning, and beliefs about teaching efficacy. She used a belief system covering interrelationships among these core beliefs (Buehl & Beck, 2015; Kilinc et al., 2013) as a lens in interpreting the nature of reform and its implications. Second, our case study showed that certain cognitive mechanisms such as "epistemic heuristic," "evidence-based justification," and "prioritization" were crucial in Duygu's resistance to change. Consistent with previous findings (Kilinc et al., 2017), it seems that her existing epistemic belief based on "teacher authority and transfer of scientific truths" heuristically influenced her interpretations of the content and practices in all stages and easily diffused into the evaluations in other core educational beliefs. Her evaluations of classroom management problems (necessity of teacher intervention) and of curricular obligations (transfer of scientific truths), for example, showed that she consistently consulted to her epistemic heuristic. Evidence-based justification, one another cognitive mechanism, was particularly influential in the presentation (AW course in our case) and first implementation (teaching practicum in our case) of the reform. It seems that the evidence types determine the nature of justification and concluding belief development. The "estimation" and "vicarious experience" that are weak evidence types, for example, result in "no change," "pseudo-change," or "emergence of new beliefs." On the other hand, "mastery

experience" that is a strong evidence type result in "reversal" or "elaboration" of previous beliefs. Finally, prioritization is particularly important in consolidation of reform efforts (induction year in our case). Perhaps prioritization is a mental calculation among different classroom activities and beliefs about them. Our results showed that regular responsibilities of school teaching was more important and urgent than reform efforts to Duygu and that she gave more of their attention, time, and energy to these responsibilities.

Why Does Resistance Occur?

Figure 4 displays the causal model for our "why" question. This figure also extends existing knowledge about pedagogical limitations (Borko, 2004; Rodriguez, 2005) that are responsible for teacher's resistance to change. Although Turkish curricular reform aims at science teachers efficiently using dialogic discourse in SSI (and science) teaching, the case of Duygu told us a different story. Duygu taught us that that there are two primary barriers to achieving this compelling change. We borrow the barrier terminology from Ertmer (2005), who used first- and second-order barriers for teachers' problems regarding technology integration. In our resistance model, first-order barriers were environmental and structural factors preventing the adoption of dialogic discourse in SSI teaching. Second-order barriers were personal factors that are related to identity, personality, and professional beliefs. We considered that first-order barriers produced second-order barriers; thus, removing first-order barriers has the potential to solve the majority of the problems at both levels to facilitate the adoption of dialogic discourse in SSI teaching.

Limited educational opportunities were one of the first-order barriers. Duygu did not have a strong educational background comprising dialogic activities. Her pre-university education was primarily teacher-centered, and Duygu generally assumed a passive learner role. Duygu also complained about the number of students in her classes. Perhaps her previous experiences produced images and models of teaching before Duygu entered the teacher education program,

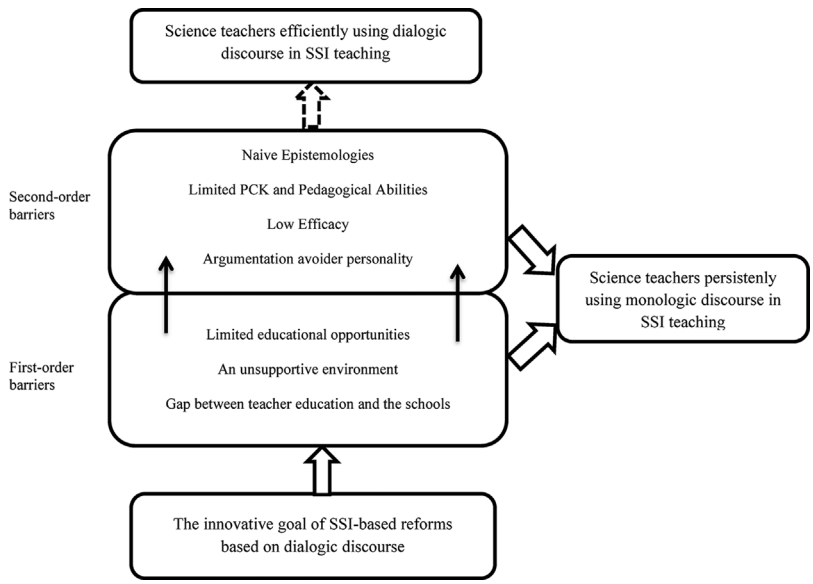

Figure 4. The case model for Duygu's resistance to dialogic discourse in SSI teaching.

and these images and models filtered proposed knowledge and practices in teacher education (Fives & Buehl, 2012). In addition, although the university should provide flexible learning environments and opportunities for self-expression, there were limited discourse-based opportunities both at the university and afterwards. Duygu criticized both the science and pedagogy courses in her teacher education. Her interpretations are consistent with previous findings about Turkish context. Aydeniz and Gurcay (2013), for example, argued that most instruction in Turkish universities takes place through a traditional teaching framework where the teacher is dispenser of knowledge and students are consumers of teachers' expert knowledge. Therefore, Turkish preservice teachers lacked competency in developing scientific arguments and knowledge of argumentation.

An unsupportive environment was another first-order barrier. Duygu clearly described how her environment during different periods of her CPD negatively affected her. Duygu believed that the majority of the teacher educators on the faculty preferred didactic teaching and did not support the PSTs in developing mastery and vicarious experiences. Similar to the participants in Sadler's (2006) work, Duygu criticized the cooperative teacher in the practicum school in which she should have vicariously learned to teach and experience real practices by modeling this teacher. The cooperative teacher did not enrich the classroom environment and only asked students to read the textbooks. Duygu also had negative experiences in the state school to which she was appointed. The principal was not supportive and did not apply discipline procedures. This discipline gap was reflected in Duygu's lessons and in other teachers' lessons. In addition, instead of gathering suggestions regarding dialogic discourse from other teachers, Duygu emphasized that the primary topic in the teachers' room was how to discipline the students. Duygu also criticized our planned AW, saying that the workshop did not include suggestions or strategies for coping with the classroom management problems that emerge in a dynamic discussion environment. These results are consistent with existing literature (e.g., Price, 2012) and move this body of knowledge one step further by showing that the sustainable support from different actors is essential in different stages of teacher's CPD.

Another first-order barrier was the *gap between the teacher education* and *the schools.* Duygu frequently specified that what was going on in the university was too different from the state schools. Although she learned certain constructivist teaching methods, Duygu could not find an opportunity to implement them because of school-based realities and perhaps because of her prioritization mechanism. In addition, she noticed that specific classroom-oriented knowledge such as the rules of discussion and argumentation strategies were not available in teacher education. It seems that these bidirectional limitations cannot be resolved by looking the issue from one side. Therefore, an organic connection between state schools and faculties of education is crucial (Gaudelli & Ousley, 2009) in order to remove this first-order barrier.

A second-order barrier that Duygu encountered was *naive epistemologies.* She persistently expressed a belief that teachers are knowledge conveyors and must pass on scientific truths. She believed that the teacher should be the primary source of knowledge and that the students should absorb the knowledge presented by the teacher rather than building the knowledge and arguments cooperatively. In a practical sense, as many other science teachers (McNeill & Knight, 2013), Duygu used QAE sessions during her teaching practicum with the correction goals. In addition, Duygu's educational goal of changing humans by interventions and her science teaching goal of raising scientific awareness appear to be fostered by the same *naive epistemology.* Considering that education was one of the sources of Duygu's epistemological beliefs (Hofer & Pintrich, 2002), perhaps her teacher-centered background at both the pre-university and university levels and the unsupportive environment in which she was exposed to epistemology-weakened situations produced such results.

Another second-order barrier was *limited pedagogical content knowledge* and *pedagogical abilities.* Because of her limited subject matter knowledge, she gave incorrect feedback to students regarding the structure of coal. This incident occurred just prior to the argumentation session, and Duygu believed that her confusion regarding the question influenced further events. Thus, we can argue that subject matter knowledge is an important dimension of dialogic discourse (Gutierez, 2015) in SSI teaching (Kilinc et al., 2013). In addition, Duygu experienced problems combining her knowledge of the coal industry, her knowledge of argumentation, her knowledge of the rules of dialogic discourse, and her knowledge of classroom discipline. For example, after building opposite groups about lignite mine, she did not intervene with students' answers in one group because she considered that the group might consider that the teacher was on their side. Similarly, she missed opportunities to connect similar arguments and summarize the argumentation processes. In addition, she used the questions only for reminding specific facts rather than starting any argumentation or further elaboration of the answers perhaps because of her limited knowledge about the components and structure of the argument (Kolsto et al., 2006; Zohar, 2007). When we asked why she did not give any feedback to the students, consistent with many other (preservice and in-service) science teachers (Gray & Bryce, 2006; Kilinc et al., 2017), she expressed that there was no conclusion to be reached in SSI discussions and therefore it would be a mistake to give feedbacks. This misunderstanding about SSI teaching caused her not to participate in the discussion. These problems resulted in loss of control over the discussion. In addition, her teaching practicum showed that she possessed poor pedagogical abilities regarding dialogic discourse. These abilities include the ability to organize discourse such as producing controversial contexts, sharing authority with the students, presenting meta-discourse explanations, asking open-ended questions, connecting students' comments, giving clear feedback, and building collaboration. Also included are the ability to manage a classroom by listening to students without interruption, efficiently involving students, and reminding students of the rules of argumentation.

Low teaching efficacy was an important barrier causing Duygu's resistance. Duygu had good vicarious experiences and enjoyed the SSI discussions in AW. Therefore, we noticed that she initiated to develop efficacy to use SSI discourse after AW. However, perhaps because of the lack of mastery experiences (Venville & Dawson, 2010) in AW, she was struggling to use this efficacy during teaching practicum and she experienced very stressful moments during classroom discussions. The classroom was very crowded and she did not have any preliminary preparation for using SSI discourse in such a classroom. These factors dramatically decreased her efficacy and caused her to give up easily (McAfee, 2015). In addition, the induction year elaborated her pessimism with the contributions of new duties such as solving problems and obligation to complete the curriculum. In addition, we believe that the actors in her environment might also be responsible (Bandura, 1997; Price, 2012) for her low teaching efficacy over the CPD. Duygu, for example, encountered an ineffective cooperative teacher in the practicum school and a principal who did not provide support for the teachers in the state school during induction.

Duygu also exhibited an *argumentation-avoider personality.* Duygu was unsociable person during her university education and preferred the listener role during discussions. This behavior also occurred during the AW, during which she was silent and unwilling to join discussion sessions. Although Duygu attributed the majority of her behavior to the crowded nature of her classrooms, she acknowledged being not sociable. We are aware that certain people prefer an argumentation-avoider role during discussions because of their personalities (Merlino, 2014). First-order barriers (e.g., the lack of opportunities to help students work collaboratively and strong teacher authority) may be responsible for the development of this characteristic in addition to other possible factors such as family environment.

Conclusions and Implications

The purpose of this single case study was to understand the nature of resistance to dialogic discourse in SSI teaching. We benefited from a range of data-collection tools to understand the process and underlying reasons for this resistance. We considered that there were two lessons to learn from Duygu's case. First, resistance to change is a complex process exceeding the boundaries of units (e.g., discourse), subjects (e.g., SSI), and subject-matter education (e.g., science education). It cannot be explained only by pedagogical limitations and inconsistencies between core beliefs and reform expectations. The cognitive mechanisms (epistemic heuristic, evidence-based justification, and prioritization), belief development processes (pseudo-change, reversal, etc.), and a range of barriers produce a complex ecosystem. We believe that any effort from curriculum makers, teacher educators, or policymakers that does not consider this ecosystem will not thrive. In other words, reductionist approaches, such as organizing an argumentation-based science teaching methods course, developing pedagogical skills for a discourse-based teaching practicum, and providing principal support for promoting discourse may be short-lived if they are not connected to each other by a system mentality.

Second, we must enrich the CPD of teachers to remove first- and second-order barriers to achieve more effective science and SSI teaching and to reach dialogic generations that can make informed decisions (Sadler, 2011) and fairly evaluate the evidence (European Union, 2012) in a broader sense. The following suggestions based on our findings may be helpful.

Before making any CPD attempt, teacher educators need to uncover (preservice and in-service) science teachers' existing belief systems about discourse-based activities because these beliefs have the potential to determine how much the teachers will benefit from CPD activities and how much they will integrate new beliefs into their existing belief systems (Simon et al., 2006). Peer-discussion environments with the participation of teacher educators may help teachers freely explain their belief systems. Through these discussions, the danger of the stabilization of certain negative beliefs may be prevented, the cognitive mechanisms that are responsible for resistance may be scrutinized, and the teachers may enrich the discussions by alternative belief systems and justification processes.

CPD should include many educational opportunities in which to experience dialogic discourse and learn how to organize it. These opportunities may be offered in science teaching courses or workshops for both preservice and in-service teachers. The PCK, teaching efficacy, and pedagogical skills for dialogic SSI teaching may frame these opportunities. Elaborating on the PCK framework of Venville and Dawson (2010), our experience with Duygu showed that the PCK for dialogic SSI teaching covers components such as subject matter knowledge, knowledge of the nature of SSI, knowledge of classroom management strategies, knowledge of dialogic discourse, knowledge of argumentation strategies, knowledge of student learning, and knowledge of the teacher's role. Any attempt to enhance science teachers' knowledge about dialogic SSI teaching needs to enhance these knowledge components and produce practical opportunities to be able to combine them. Regarding teaching efficacy, CPD needs to include many opportunities of mastery experience in addition to vicarious ones because these opportunities are necessary to produce practical evidence for enhancing or replacing existing beliefs. In addition, principal and collegial support in using dialogic discourse is crucial. The pedagogical skills of science teachers regarding speaking moves, argumentation, efficient course planning, questioning, communication, classroom management, student nomination, and collaborative learning need also be developed. We believe that these educational opportunities should be long term (Martin & Hand, 2009) and include adequate environmental support and follow up.

The gap between schools and teacher education should be bridged by better communication channels and realistic goals. In practical sense, participatory action attempts based on the development of lesson plans for dialogic SSI teaching with the help of action research groups including science teachers, teacher educators, and PSTs may be helpful (Feierabend & Eilks, 2010). In addition, attention should be given to the selection of practicum schools. Efficient cooperative teachers who frequently use dialogic discourse activities need to be at the top in the list of candidates. In addition, enough time needs to be left for classroom observations so that preservice teachers observe the problems in classroom discourse (e.g., misbehaviors of students, face-to-face debates) and reflect on the solutions of cooperative teachers. In addition, science teaching courses that include reform-based activities such as dialogic SSI teaching need to be tailored to the obligations of science teachers in state schools, such as preparing students for national examinations and completing the curriculum on time. Through this reorganization, beginning teachers will not struggle to diffuse dialogic SSI teaching into real classrooms in their induction period.

Finally, teacher epistemologies appear to be a strong barrier to discourse-based activities (Kilinc et al., 2017). Therefore, epistemology-enhancement opportunities in each stage of CPD should be created. These attempts need to target science teachers' naïve epistemologies (e.g., teachers are conveyors of scientific truths) and replace them with more sophisticated versions (e.g., teachers are facilitators in reaching best arguments) that are necessary for dialogic SSI teaching.

Limitations and Future Perspectives

As all scientific research does, the present research includes certain limitations. First, we organized a single case study. The quantitative generalizability of such research is limited. Although case studies target theoretical generalizability (Yin, 2013), we question the prevalence of our resistance models (mechanisms, processes, and causal models) in other samples and in other reform efforts (e.g., teacher's resistance to STEM activities). Comparative case studies and survey research may produce findings in this area.

Second, the SSI-Discourse Types Questionnaire (SSI-DTQ) included vignettes representing monologic and dialogic discourse in SSI teaching. We adopted this simple approach because many researchers have used these extremes and because we benefited from a range of data-collection tools in addition to the SSI-DTQ. However, considering the dynamic nature of classroom interactions, we believe that there may be combinations of these discourses (e.g., authoritative-interactive, dialogic-interactive, authoritative-non-interactive, dialogic-non-interactive; Scott et al., 2006). Examining teachers' reactions to these alternatives during CPD may be another research idea.

Finally, we did not organize a long-term professional development in the present study. Our 2-day argumentation-based workshop did not include PCK about dialogic discourse, classroom management strategies, or micro-teaching activities for preservice teachers. In addition, Duygu observed an unsupportive cooperative teacher in her teaching practicum. Similarly, she was appointed to a middle school where discipline problems pervaded all educational activities. These specific conditions might build a specific belief system of resistance. We wonder whether teachers may present resistance even if they experience a sustainable professional development with better conditions in classroom contexts. Conceiving such research and pursuing the development of resistance will enhance the body of knowledge we produced in the present study, enabling us to better understand the nature of resistance and the effects of positive and negative conditions on it.

Note

[1]Adopting the Teaching Council (2011)'s perspective, we believe that the Continuum of Professional Development approach covering both initial teacher education (ITE) and in-service teacher education would better explain the professional development attempts.

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