Education and Science

Original Article

Vol 48 (2023) No 215 201-242

Challenges to Novelty: Changes in Barriers Facing Primary School Teachers *

Yasemin Büyükşahin [1], Sevgi Kıngır [2]

Abstract

Professional development programs enable teachers to familiarize themselves with new teaching methods. However, practicing what one learns in the process depends on one's internalization. This study aims to present how teachers manage these processes of acceptance. A professional development model supporting teachers was created for this long-term case study, which observed the teachers' development. A 3-day hands-on training program was organized for a group of volunteer teachers, three of whom were provided with on-the-job support for one academic year. During the on-the-job support process provided through scaffolding, internal barriers against new applications were identified. Changes in these barriers were classified into affective and communicative categories and presented holistically in this study.

Keywords

Affective barriers
Communicative barriers
Inquiry-based science teaching
Primary school teaching
Professional development program

Article Info

Received: 01.31.2022
Accepted: 05.11.2023
Published Online: 07.26.2023

DOI: 10.15390/EB.2023.11589

Introduction

Teachers who are responsible for education in society should renew themselves over time. In today's world, where information develops and changes rapidly, it is natural to have gaps between periods of training that teachers received at university and current demands of education provided to students. Closing the gap is possible with the professional development programs for teachers. Professional development is maintained with in-service training programs. The main aim of in-service trainings is the acquisition of new knowledge and skills in line with current developments in education for teachers (Kennedy, 2014). It is difficult for teachers to modify their teaching methods. This process that Gess-Newsome (2001) described as leaving the reliable and familiar and moving toward the new and indefinite brings conflicts continued by either internal or external factors. What is the driving force that ensures this continuity?

Sometimes requisite innovations are imposed on employees by employers, and individuals head toward situations they feel incapable in themselves. This learning process, maintained by internal and external factors, is made permanent by adopting change. As in all occupational groups, learning in teaching profession is a multifaceted process. Teachers can sometimes learn by making inferences from the solutions of daily life problems, sometimes by having conversations with colleagues and sometimes

* This article is derived from Yasemin Büyükşahin's PhD dissertation entitled "Monitoring classroom teachers' development during professional development program for inquiry based science teaching", conducted under the supervision of Sevgi Kıngır.

[1] Bartın University, Faculty of Education, Department of Primary Education, Turkey, yasemin.buyuksahin@gmail.com
[2] Hacettepe University, Faculty of Education, Department of Early and Elementary Education, Turkey, kingirsevgi@gmail.com

by having experience with students (Borko, 2004). However, according to Borko (2004), the evolution of this learning process toward professional development can be achieved with systematic practices. Practices that are defined as professional development system are based on the triangle of facilitators, professional development program and teachers. The teacher is the person who learns during the process. Professional development program refers to the practices that improve teacher knowledge and skills; and facilitators are those who guide teachers for new learning in this process. From this perspective, a scaffolding-based professional development model was developed and applied in this research to describe the change process of teachers. The driving force that will ensure continuity in professional development, which is defined as a difficult process involving change, is the internal resources of the person. Internal resources that accelerate and slow down this change process were chosen as the focus of the research.

Teachers' Professional Development Process

Teachers' professional development can be described as gaining knowledge and skills and improving attitudes (Aldahmash, Alamri, & Aljallal, 2019; Kennedy, 2005). The professional development process helps teachers obtain the necessary skills to work most efficiently from their first day to retirement (Ozer, 2008). The steps taken to become an expert at work are called professionalism, which stirs controversy. According to Sachs (2001), professionalism can be managerial or democratic. Managerial professionalism values effectiveness and abides by policy, while democratic professionalism ensures social justice, objectivity, and equality. With democratic professionalism, teachers provide the development necessary for themselves and their class (Kennedy, 2007; Santoro & Kennedy, 2016).

According to Smyth, Dow, Hattam, Reid, and Shacklock (2000), although the democratic professionalism model started being used in the literature, the managerial model related to globalization is undoubtedly more prevalent. Managerial professionalism dominant in performance management and accounting has led to a new concept of professionalism (King, 2011). Professional development, however, is not standardized, and teachers use either model based on their existing needs and school requirements (Bell & Bolam, 2010).

According to Borko (2004), teacher change focuses on characteristic knowledge for teaching, understanding student opinions, and selecting teaching applications. Research has shown that intense professional development programs change teachers' knowledge and applications (Borko, 2004; Dolfing, Prins, Bulte, Pilot, & Vermunt, 2021; Franke, Carpenter, Levi, & Fennema, 2001). Additionally, it has been shown that through standardized teaching, only professional developments with more than 80 hours of practice resulted in change (Cohen & Hill, 1998; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Supovitz & Turner, 2000).

Loucks-Horsley et al. (1998) proposed that real change is only possible through developing and experiencing a new understanding. It is unjust to expect teachers to change their approaches suddenly to accept the changing process (Hanley, Wilson, Holligan, & Elliott, 2020; Loucks-Horsley et al., 1998). Change occurs when development programs present teachers with keys for students' sense-making. Studies that support professional development amplify teaching clues, offer active learning opportunities, enable teachers to adopt applications, and are collaborative and long-term (Darling-Hammond & Richardson, 2009). However, short-term professional development programs where teachers are passive recipients of knowledge are ineffective and teachers may have difficulty in putting the transmitted knowledge into practice when they are alone in the classroom (Lamb, 1995). Kennedy (2014) categorized models necessary for teachers' in-service professional development under eight titles (p. 693). These models and their purposes are presented in Table 1.

Table 1. Professional Development Models for Teachers and their Purposes

Purpose	Professional development model	
Transfer	Training model	
	Deficit model	
	Cascade model	Increasing capacity for professional autonomy and teacher agency
Formation	Award bearing model	
	Standard-based model	
	Mentoring model	
	Community of Practice model	
Transformation	Collaborative professional inquiry model	

The purposes of the models increase in terms of rate of teacher change from the top to the bottom in Table 1. The training, deficit, and cascade models at the top only transfer knowledge. The award, standards, mentoring, and community of practice models aim to establish professionalism in teachers. In these formation (establishment) models, the presented knowledge is expected to affect teachers. The philosophy of transformation models is to maintain learner-centered education pedagogy. This collaborative model attempts to change teachers' teaching philosophies. Some research indicates that learner-centered methods have currently been adopted by education policies in many parts of the world including Turkey; however, teachers may not have adopted the process yet (Buck, 1996; Deboer, 2002; Ecevit & Simsek, 2017; Fidan & Duman, 2014; Kaptan Acar & Taşdemir, 2017; Kilic, 2018; Nuckles, 2000; Ozenc & Dogan, 2007; Wang, 2011). This may be due to teachers' barriers against change called "instructional barriers." They can be related to teacher pedagogy and affected by individual barriers or external sources.

There are many studies that show the positive effects of in-service teacher training on teacher pedagogical knowledge and skills and student success (Academy for Educational Development, 2002; Borko et al., 2005; Grossman, Wineburg, & Woolworth, 2001; King, 2011; Mulholland & Wallace, 2005; Opfer & Pedder, 2011; Sachs, 2016; Smith, 2007). Franke et al. (2001) define in-service teacher training as a process that helps to develop individuals' learning skills and they emphasize the effectiveness of quality in-service teacher training. However, in-service teacher training studies conducted in Türkiye generally focus on teachers' views on the training provided and their expectations from in-service training (Bümen, Ateş, Çakar, Ural, & Acar, 2012; Demir, Böyük, & Erol, 2012; Kaçan, 2004; Karaaslan, 2003).

In-service training and its importance is emphasized by studies conducted in many countries in terms of sustainability of the profession, which are often carried out by universities and social institutions. In-service training is led by the Ministry of National Education (MoNE), General Directorate of Teacher Training and Development, Professional Development Support and Monitoring Department in Türkiye (Şişman, 2009). The establishment of these institutions in the 1960s has broadened the field of study related to the training of novice teachers since 1982. Until 2010, the effects of the process have been the subject of many studies (Büyüköztürk, Akbaba-Altun, & Yıldırım, 2010; Kıldan & Temel, 2008; Ozer, 2008; Pusmaz, 2008). In 2010, a "Panel and Workshop on the Restructuring of In-service Training" was held (MoNE, 2010) and fundamental decisions were taken in the councils held thereafter. However, none of the mentioned decisions were put into practice; such as, having each teacher participate in in-service training at least once per three years, establishment of the National Education Teacher Academy, crediting in-service trainings provided to teachers, and moving teachers to higher stages of development (Güven, Alagöz-Hamzaj, & Baldan, 2016).

When the literature focusing on professional development of teachers is reviewed in general, it is remarkable to realize that the studies were intensely carried out in late 1900s and early 2000s. Countries that got out of the two world wars have made various breakthroughs with the concern of keeping political and economic power. Countries that have succeeded in getting out of difficult times with the keys of science and industry have proceeded this process with educational reforms. Education policies aimed at educating students to be proficient in science also focused more on in-service teacher training. Educational reform projects have emphasized inquiry-based applications and aimed to teach how science is done rather than what it is. It is thus deemed appropriate to plan and define the scope of the current in-service training model with inquiry-based science teaching as it has been widely adopted in science classrooms around the world.

Inquiry-based science teaching and professional development

Inquiry-based teaching began to come around in the 1950s in the Western society, which valued raising qualified work force. This teaching philosophy aims to provide children with the keys to the doors of science, rather than teaching science. The child, who has mastered the ways of producing scientific knowledge, would become part of a qualified work force as an individual who has learned to learn. Pioneers of this teaching method based on constructivist philosophy are the scientists such as John Dewey, David Ausubel, Jerome Bruner and Jean Piaget. Although the concept of "inquiry", which was first used by Joseph Schwab (1962), took its place in educational reforms around the world, it entered into our country procedurally for the first time in 2013 via science curriculum (MoNE, 2013).

Inquiry-based teaching, which is classified as structured, guided and open-ended by Martin (2012), can be applied to different groups according to student readiness and cognitive level. Structured inquiry has guidelines which are more appropriate for younger students. In structured inquiry, research question and procedure are provided by the teacher, the students participate in the inquiry process with the teacher. Guided inquiry, which can be used at primary school level, requires the teacher to take the role of a person who initiates the process with intriguing questions, problems or case studies and guide the student during inquiry process. In open-ended inquiry, which is more likely to be pursued with upper level students, the teacher assumes a role as a guide. Students ask their own questions, design and carry out investigations to test their hypothesis with own variables and methods (Windschitl, 2003). As can be seen in all three levels of inquiry described briefly, there are commonly used skills such as asking questions, identifying and controlling variables, testing and drawing conclusions in the teaching environment. There is an intense discussion, inquiry and experimentation process in the classroom (Martin & Hand, 2009). This process is different from standard classroom practices in such a way that a student-centered approach is implemented, the seating arrangement is different from the classical layout, and students generate knowledge by working in groups (Llewellyn, 2002). Therefore, it may cause teachers who are accustomed to lecturing in front of the board to feel insecure about their authority (Pierce, 2001).

The main responsibilities of a teacher who implements inquiry-based teaching are to make process-oriented plans; to evaluate the process without being stuck with the results; to encourage and involve students in the process; to organize a learning environment that promotes curiosity and investigation; to encourage students to use scientific process skills; to provide interpretation of the subject matter with metacognitive skills; and to guide students to apply acquired knowledge to daily life (Martin, 2012). If the teacher cannot fulfill these responsibilities, the teacher and students may find themselves in an aimless drift and experience a decrease in motivation (Pierce, 2001). A teacher who wants to pursue inquiry-based practices needs to possess positive attitudes, and high levels of self-confidence, self-efficacy and motivation toward teaching and learning to run all these processes; and have effective communication and interaction skills to promote a productive and positive learning environment (Llewellyn, 2002).

Teacher development is a process that has effects not just limited to teachers alone. Teachers renew their teaching methods during this development process, and affects their students as well as all the teachers around. Murphy (2005) attempted to explain this process in instructional, relational and

enabling dimensions. According to Murphy, a teacher who makes progress changes the teaching processes, establishes more positive relationships with the teachers and students around, and provides facilities for the change process of others. Considering aforementioned effects while designing teacher development process, the issues that can help or vice versa prevent teachers should be determined. Barriers should be reduced while making use of supplementary sources.

Instructional Barriers

Instructional barriers comprise all matters hindering the teaching and learning process (Johnson, 2006). Anderson (1996) divides these barriers into technical, political, and cultural dimensions. Technical barriers relate to teachers' knowledge of subject areas, pedagogical knowledge, and teaching skills. Political barriers are lack of source and support. Cultural barriers relate to education-related beliefs and values (Anderson, 1996, 2002; Anderson & Helms, 2001).

Internal barriers originate from teachers and they include beliefs, attitudes, knowledge, and skills. Barriers are the biggest blocks to change. If a person does not see change as a need and does not want it, no force can achieve this change completely. There are some theories that have been proposed about the process of change. According to one of these theories, namely the theory of planned behavior, the factors that affect an individual's behavior are modeled (Ajzen, 1991). Intention represents a person's mental processes to perform a behavior. Factors constituting the intention include attitude, subjective norm, and perceived behavioral control. In the attitude factor, there are beliefs, expectations, and evaluations of individuals toward the behavior. Normative beliefs are effective in the subjective norm factor. These are motivation toward the behavior, and social pressures that individuals perceive about the behavior. In the perceived behavioral control factor, perceptions of the difficulties or conveniences that might be experienced when performing the behavior are effective (Erten, 2002).

Within the framework of the theory of planned behavior, a radical change in the teaching practices of teachers can be achieved by positively affecting their attitudes toward the change and new processes; minimizing pressures from teachers, parents and administrators around them, and eliminating perceived mental obstacles in front of change. These obstacles, named as internal barriers, are emphasized by Lieberman, Saxl, and Miles (2000) with the concept of "self-esteem", which is an important point that should be especially considered while introducing the teacher development process. Self-esteem, which is also defined as a positive mood that enables a person to be self-confident, is at the top of the individual's success ladder according to Maslow (1958) (Yörükoğlu, 2000). Necessary conditions to achieve teacher change are to increase attitude, motivation and self-confidence, and in turn increase self-esteem with the support provided to the teacher. All these issues are considered as internal barriers to a teacher's acceptance of innovation within the scope of this research. All factors outside the teacher's inner world, such as financial problems, student apathy, administrative reluctance, colleague attitude and interpersonal relations, can be classified under external barriers. The barriers investigated in three dimensions by Anderson (1996) and subsequently discussed in many articles are limited to internal barriers to change in this study (Anderson, 2002; Anderson & Helms, 2001; Johnson, 2006; Kielborn & Gilmer, 1999; Soysal & Tanik, 2017; Yoon, Joung, & Kim, 2011).

This study differs from previous works because it focuses on internal barriers and attempts to describe processes to eliminate them. This study is built on the idea that it is necessary to avoid the external to reveal the internal because individuals prefer commenting through external barriers when questioned about internal ones (Zimmerman, 2000). For instance, when teachers are asked why they avoid new methods, they generally list external barriers like requiring too many materials, financial problems of students, indifference of school management, difficulty catching up with the curriculum, etc. It is difficult to confess that they fear losing control of their class, their authority, and self-confidence. In a study conducted by Sanchez (2012) the issues affecting teachers' use of new knowledge when planning an instruction were classified as internal and external factors. According to Sanchez, possible mistakes when using new information, and fear of humiliation in the eyes of learners are internal factors affecting the teacher. Andrews (2007) emphasizes that it is possible to manage teacher change by contextual factors such as time, behavioral factors such as attitude, and professional factors such as

content knowledge. Although it is classified differently by different researchers, the importance and diversity of factors affecting teacher change is remarkable. It is difficult to claim an in-service training model in which teachers can be guaranteed to transfer what they have learned directly to their class without focusing on the variation of these factors (Dikilitaş, 2013). Therefore, this study minimized external barriers by utilizing the inquiry-based teaching method proposed in the science curriculum.

The model was based on scaffolding, which enables maximum authority. On-the-job support provided with scaffolding prevented external factors from affecting the process. Since teachers require time and freedom to adopt an inquiry-based, learner-centered method, internal barriers can be changed by advisors rather than people presenting knowledge (Buck, 1996). Consequently, the professional development model was designed to be collaborative, applicable, shareable, long-term, and in accordance with the education policy. The method section presents the model with the development process. Specifically, the research questions guiding this study are:

1. Which internal barriers stop or delay teachers' adoption of the inquiry-based teaching method?
2. What is the effect of the professional development model on teachers' internal barriers?

Method

This research was conducted with a qualitative case study methodology with the aim of examining development process of teachers in depth. A natural data collection process was carried out in the natural environment of the participants. Case study was preferred due to the research structure that reveals the system within the framework of real life and certain limits. The process was initiated using specific themes, shaped by the data collected, and interpreted based on the findings. The boundary of the case caused a generalization problem, which was managed using a multiple case study approach. Possible problems occurring in multiple case studies were considered (Yin, 2009). Accordingly, repetition of the same process was considered. Individual teachers and their classes were considered distinct cases and evaluated separately during the interpretation. A multiple case approach rather than case comparison ensured generalizable results during interpretation. Additionally, multiple case studies clarify the common process between different cases (Miles & Huberman, 1994). Processes were handled cautiously by considering possible issues related to multiple case studies to ensure homogeneity.

Participants

Participant teachers were selected using purposeful criterion sampling, in which all cases with the established criteria are comprehensively examined (Patton, 2005). The five criteria in the study for participant teachers were: participate in the training held by the researchers which covered inquiry-based science teaching practices, not receiving an in-service training including on-the-job support and inquiry-based science education before, working as a primary school teacher, teaching fourth graders during the specified study period, and working in the city where the study took place. The number of participants for this training was determined to be high for this purpose. Out of 17 participants, 3 volunteered for the study. Relevant information has been presented in Table 2, and pseudonyms have been used.

Table 2. Demographic Information of Participant Teachers

Pseudonym	School	Gender	Age	Experience	Graduation
Ceren	B. Primary School	Female	34	13	Primary school teaching
Murat	A. Primary School	Male	47	21	German language and literature
Sema	I. Primary School	Female	47	26	French language teaching

Ceren, who works at B. primary school, is a 34-year-old female with a bachelor of education degree and 13 years of teaching experience. B. primary school is a city-affiliated village school offering mobile teaching for students from villages located within 26-40 km from the city center. Low-income families dependent on agriculture and husbandry live in these villages. The school has 202 students, an adequate number of classrooms, and a schoolyard.

Murat from A. primary school is a 47-year old male with 21 years of teaching experience. His degree is in German language and literature, but he became a primary school teacher after the appropriate short-term training program. A. school is a village school located 5 km from the city with which it is affiliated. It offers mobile teaching for the surrounding villages inhabited by middle-income families. The school has 204 students, an adequate number of classrooms, and a schoolyard.

Sema from I. primary school is a 47-year-old female with 26 years of teaching experience. Her degree is in French teaching, but she became a primary school teacher. The school has 726 students, is one of the most crowded schools in the city, and is centrally located. It has two school buildings, which are physically inadequate. The parents generally have fixed incomes and they are socio-economically upper-middle.

Description of the Professional Development Program

Following the literature review, a professional development model for teachers was drafted by the researchers (Bell & Bolam, 2010; Cohen & Hill, 1998; Darling-Hammond & Richardson, 2009; Kennedy, 2007, 2014; Loucks-Horsley et al., 1998; Supovitz & Turner, 2000). The most important point of the model shown in Figure 1 is the scaffolding-based support, which was generously provided at the beginning, decreased gradually, and then ceased.

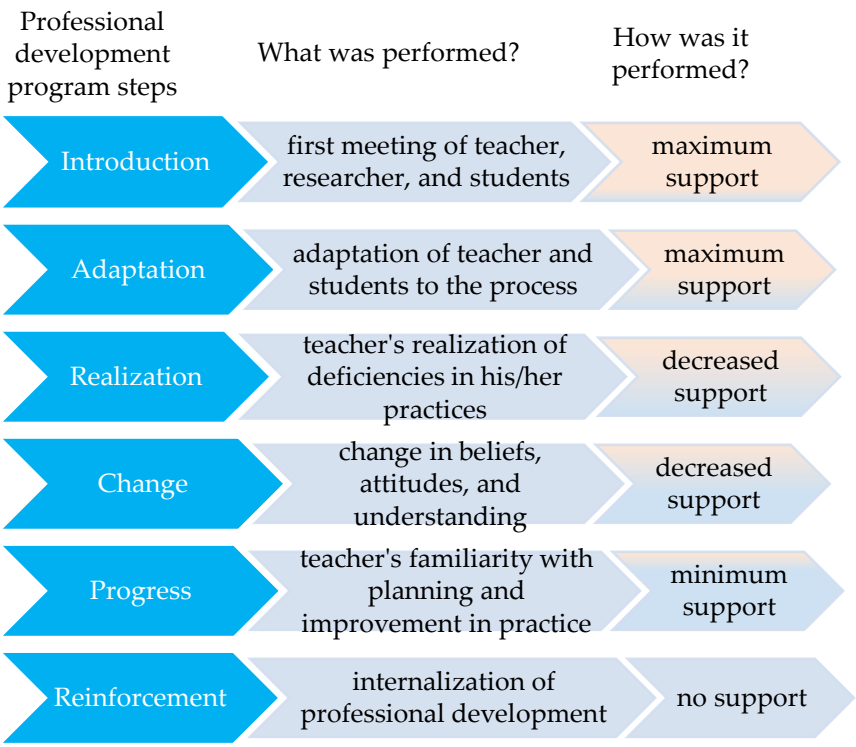


Figure 1. Scaffolding-based professional development model

In the inquiry-based science teaching applications, support was provided equally to the participant teachers. Each teacher was provided the same activity plans and amount of materials, and the same applications were performed in each class. In this respect, weekly support, defined as scaffolding in the literature, was decreased gradually (Hogan & Pressley, 1997). Using a construction analogy, a scaffold is erected first, which helps construction, and as the building is completed, the scaffold is dismantled. Similarly, support in teachers' professional development was gradually eliminated as they started proper applications. The program steps are presented in brief in Table 3.

Table 3. Teacher Professional Development Program Steps for Inquiry-based Science Teaching

Program steps	Duration	What was done?	What was achieved?
Introduction	2 weeks	3-day workshop of applied teacher training	Teachers and researcher communicated. Teachers realized the need for inquiry-based teaching and learned its application steps.
Adaptation	1. week 2. week 3. week 4. week	Researcher planning – researcher application	Teacher and students adapted to the inquiry-based teaching process.
Realization	5. week 6. week 7. week 8. week 9. week 10. week	Researcher planning – teacher application	Teachers started implementation and realized their shortcomings.
Change	11. week 12. week 13. week 14. week	Researcher planning – teacher application	Barriers were changed.
Progress	15. week 16. week 17. week 18. week	Teacher planning and application -researcher plan support	Adaptation to planning was achieved; practice improved.
Reinforcement	19. week	Teacher planning and application -researcher idea support	New application was reinforced.
	20. week	Application without guidance	New application was adopted.

During the training in the introduction step, inquiry-based science teaching activities were practiced. At the end of each day, in-class applications were discussed. Following the teacher training, three volunteer teachers were selected as participants. Throughout the academic year, these participants applied 20 inquiry-based science activities. Before each activity, teacher-researcher meetings were held to discuss the application process and plan it. The previous week's weaknesses and strengths were discussed, and clips from classroom video recordings were used to highlight the teachers' strengths and shortcomings.

During the initial weeks, lessons were taught by the researcher (first author) in order to ease the teachers and students into the process. At week 5, lessons planned by researcher were taught by the teachers. Teachers started planning lessons at week 15. The teachers stopped receiving support at weeks 19 and 20. Transition between steps was decided by the researcher based on in-class observations. To ensure homogeneity between cases, joint actions were taken. For instance, a teacher who could transition from change to progress earlier waited for others. Teachers generally transitioned simultaneously.

Data Collection Tools

Student and teacher interview forms, a teacher observation form, a researcher diary, and video recordings were used to collect data.

Teacher Interviews

Semi-structured interviews were conducted with teachers at the beginning and end of the application. Interviews during the semester break were conversational.

At the beginning, all information was considered valuable for flexibility and comprehensive 33-question interviews were conducted. Their attitude toward science, teaching approaches, in-class communication, science literacy level, and instructional barriers were identified. These interviews were detailed and long because they also had the sub-purpose of acquiring information about the teachers and students. Each interview lasted approximately 70 minutes. The post-interview focused more on the teachers' perception of the method. Since the teacher's view of progress was desired, curriculum, method, application process, and negative and positive points were addressed. The semi-structured post-interview, which lasted approximately 60 minutes, consisted of six questions. The interview form was examined for alternative questions and detailed answers. Its validity was checked by an assessment and an evaluation expert.

The unstructured interview during the semester break was conversational. Although the same conversations were held with each teacher, the questions were unstructured due to the teachers' individual differences. Their main purpose was to identify how the teachers perceived their development in the process. Each interview lasted approximately 80 minutes.

Student Focus Group Interview

Students attended focus group interviews to identify teacher development and behavior change. Managing the process in groups instead of individually ensured that students heard other opinions and highlighted different ideas (Patton, 2005). Moreover, within-group interactions provided data regarding the communication aspect of the study. Students were randomly grouped for the interview. The number of group participants, suggested as 6-10 (Barbour, 2008), was finalized at 6-8. Since the interviews were conducted by the researcher (first author) with whom students had interacted throughout the semester, establishing trust and rapport with the participants were reinforced. The interviews were conducted at the end of the year and lasted nearly 40 minutes. The number of students and questions were limited to ensure a focused interview. The 8-question semi-structured form was consulted to the opinion of a psychological counseling and guidance expert.

Teacher Observation Form

An observation form was designed after the teachers' pre-interview. The teachers' barriers that were considered communicative were included in the form because they were observable. Control lists for their communicative approach and discourse pattern were prepared by the researchers and assessed by an expert. The structured form ensured that communicative approach and discourse pattern could be observed separately in the introduction, development, and conclusion parts of a lesson. The researcher (first author) made natural observations as a participant. The form was filled in during the lesson; however, video recordings were also utilized to transcribe discourse pattern dialogues.

Video Recordings

The researcher (first author) made observations during the process, which may have caused some details to be missed. Therefore, retrospective observation was enabled by video recordings, which also allowed for noting down the in-class interactions. During the 20-week process, the researcher recorded approximately 120-minute long weekly videos of each teacher, which totaled to 108 hours for the three teachers.

Researcher Diary

The researcher (first author) maintained a diary on the systematic development of the teachers, students, and herself. The notes were unstructured. They comprised texts narrating the process in its natural course in first person. Their length varied from a few pages to a few paragraphs depending on the researcher's psychological state. The training and application process was covered by 42 pages of notes.

Data Analysis

Multiple case study analysis requires synthesizing cases. Between-case analysis increases generalizability and deepens comprehension and interpretation (Creswell, 2013). In this study, case-oriented strategies were used in the between-case analysis. Similar and different findings were interpreted. A general conclusion was inferred by synthesizing the data (Yin, 2009). Between-case synthesis was conducted using a time-ordered meta-matrix from time-ordered displays.

Interview Analysis

Interviews were analyzed using descriptive and content analyses. The semi-structured interviews were interpreted using content analysis, and the conversational interviews were interpreted using descriptive analysis. Themes were created for both. Codes generated using content analysis were collated under themes. In the descriptive analysis, the data gathered and interpreted within the framework of certain themes were supported by direct quotations and presented by emphasizing the relations between the themes. The data about teachers' development levels were classified as beginning, decreasing support, and without support. Participants' quotes were often included to ensure reliability. 20% of the codes were checked by an expert science educator as a second coder. Miles and Huberman's (1994) formula (i.e., the number of agreements divided by the total number of agreements plus disagreements) was used to calculate compatibility between two coders. Intercoder reliability coefficients were calculated to be 87%, 84%, 92%, and 94% for pre-interviews, conversations, post-interviews, and student focus groups, respectively. Each coder recoded in a given period after pre-coding to ensure internal consistency. Finally, internal consistency coefficients were calculated as 94% and 92% for the researcher (first author) and second coder, respectively, which can be considered reliable (Miles & Huberman, 1994).

Analysis of Observation Forms

The forms were categorized by the researcher (first author) during lessons and/or while watching video recordings afterwards. The introductions, content, and evaluations of the lessons were examined. The communicative approach and discourse pattern of these parts of each lesson were noted by the researcher. The 20-week process was presented in tables and charts, increasing comprehensibility. Within-class communication was categorized as authoritative or dialogical and interactive or noninteractive. Ideas center on the teacher in authoritative discourse. If authoritative/noninteractive, the teacher presents his/her own opinion to students. If authoritative/interactive, he/she asks questions and guides students to unite them around an opinion. In dialogical discourse, teachers and students propose ideas. If dialogical/noninteractive, the teacher presents different opinions; their similarities and differences are determined. If dialogical/interactive, different ideas are produced collaboratively by teacher and students (Scott, Mortimer, & Aguiar, 2006).

Discourse pattern models are classified as triadic and chain. The chain model follows an initiation-response-feedback-response-feedback pattern. The process starts with a question by the teacher or student, followed by an answer addressed to someone else without evaluation. The triadic model follows an initiation-response-feedback pattern. The process starts with a question; an answer is obtained and then evaluative feedback is received. Generally, the teacher asks, the student responds, and the teacher evaluates verbally or nonverbally (Mortimer & Scott, 2003).

The categorizations were based on communicative approaches by Scott et al. (2006) and discourse pattern models by Mortimer and Scott (2003). For reliability, each teacher was observed four times by two experts, one a primary school teaching expert, the other a psychological guidance and

counseling expert. When intercoder reliability was calculated using Miles and Huberman's (1994) formula in the first application, the consistency of the psychological guidance and counseling expert with the researcher was 91%, and that of the primary school teaching expert was 93%. Intercoder agreement was reached and maintained in the process.

Analysis of Video Recordings

Video recordings were transcribed; a 164-page data record with comprehensible dialogues was obtained. They were interpreted using discourse analysis, a social method focusing on the mental components of communications (Elliott, 1996). Its main purpose is to elaborate on the subject within a socio-cultural context beyond the syntactic and semantic boundaries of language (Barker & Galasinski, 2001). Therefore, nonverbal elements were also taken into consideration in transcriptions with which discourse types and patterns were determined and exemplified. These dialogues were used to support data obtained from observation forms.

Analysis of Researcher Diary

The researcher's diary notes of the process were subjected to descriptive analysis, especially after post-activity applications. Notes related to research findings were used as supportive data along with quotes.

Validity, Reliability, and Ethics

Validity is a strength of qualitative research. It determines, from the reader's perspective, whether findings match reality (Creswell & Miller, 2000). According to Patton (2005), some criteria are required to increase quality. Threats and precautions for the study are presented in Table 4.

Table 4. Possible Threats and Precautions taken for Valid, Reliable Research Results

Threats	Precautions
Objectivity	Qualitative studies are innately subjective. To convert this into an advantage and make each reader feel the same, a control mechanism including different people was created. In qualitative coding, support was received from an external auditor. Intercoder consistency coefficients were calculated. 20% of observations were coded by two experts along with the researcher. Findings were obtained by ensuring agreement between observers.
Valid data	To ensure data validity in the observation forms, video recordings were utilized. Pre- and post-interview transcripts were checked by interviewees for qualitative data validity.
Systematic field study	The study encompassed one academic year. Applications continued for 20 weeks, excluding holidays and situations preventing lessons. Before and after application, meetings providing necessary information and feedbacks were arranged with teachers, which enabled the process to continue regularly. The process was maintained uninterruptedly with each teacher.
Triangulation	Resource and analyzer triangulation was used in the study. Resource triangulation ensured consistency control by using different resources for the same data. For instance, for teachers' communicative barriers, data were collected through semi-structured interviews, observations, and researcher diaries. In analyzer triangulation, different people worked for findings, and consistency was considered.
Findings reflecting data	To corroborate that findings reflected data, video recordings were transcribed. Findings were obtained from dialogues using discourse analysis and were used to support other data.
Authenticity	The researcher ensured authenticity in procedural application through a literature review before the study.
Intelligibility	To ensure comprehensible relationships between findings and different data resources, controls were performed by two language experts. They were also checked by a psychological guidance and counseling expert and a primary school teaching expert who were external observers.
Generalizability	Qualitative studies are limited by their restricted generalizability, for which multiple case studies functioned as a precaution. Results of three different teachers and their students enabled generalization.
Contribution to theory	This study is unique in the field with its long-term application in primary school and its contribution to teacher development with on-the-job support. Therefore, identifying teacher barriers and extinction phases during the model's application is expected to contribute to science teaching and teachers' professional development studies.

Findings

Barriers identified by analyzing data from pre-interviews and weekly observation forms were themed as interest, attitude, motivation, self-confidence, communication, and interaction. They were organized under two main themes: Affective domain barriers and communicative barriers (Figure 2).

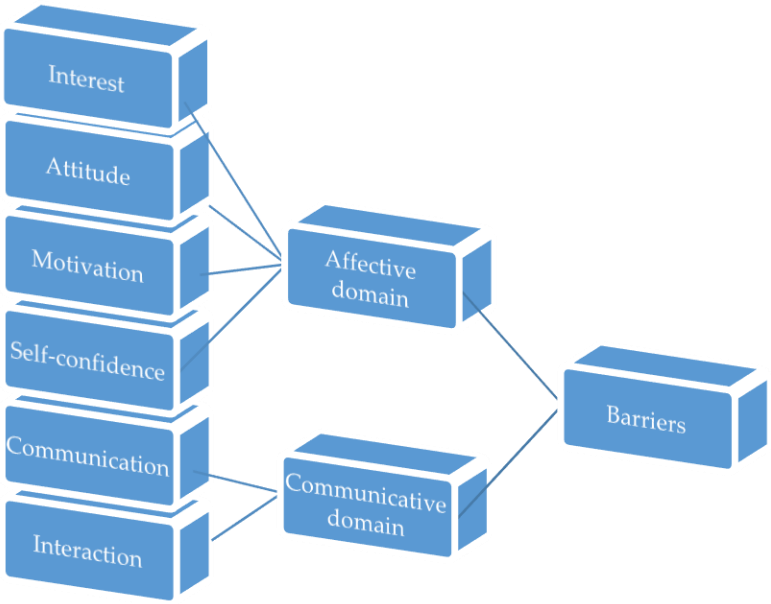


Figure 2. Barriers that hinder or aid teachers in a changeover

Affective development interacts with communicative development. The two interconnected domains grow together. Each teacher's existing barriers and the extinction phases of these barriers via zones of development were presented under relevant titles during the study.

The Effect of the Professional Development Program for Inquiry-Based Science Teaching on Primary School Teachers' Affective Barriers

The affective domain comprises internal barriers related to interest, attitude, motivation, and self-confidence. Teachers' interest and attitude affect their motivation and self-confidence, which create mental barriers against something new. In Table 5, changes in the three teachers' affective barriers are presented with the program steps.

Table 5. Changes in Affective Barriers during the Program

		Affective barriers			
Program steps	**Teacher**	**Interest**	**Attitude**	**Motivation**	**Self-confidence**
Introduction,	Murat	High	Medium	Medium	High
Adaptation	Ceren	High	High	Medium	High
	Sema	Medium	Medium	Low	Medium
Realization,	Murat	High	Medium	Low	Medium
Change, Progress	Ceren	High	High	Medium	Medium
	Sema	High	High	Medium	Medium
Reinforcement	Murat	High	High	High	High
	Ceren	High	High	Medium	High
	Sema	High	High	High	Medium

Teachers' affective developments are presented in three stages in Table 5. The first stage includes the introduction and adaptation steps and shows the teachers' temperament at the beginning. The second stage describes their development with decreased support during realization, change, and progress. The final stage involves the without-support reinforcement step and post-application findings. Levels were determined using teachers' statements and coded by researchers as high, medium, and low. For instance, mostly positive responses to questions about attitude indicated a high level,

mostly negative responses indicated a low level, and both positive and negative responses indicated a medium level. The researcher used the diary notes as supportive data in this categorization.

In terms of the affective domain, Murat started and completed the process with high levels, although his self-confidence dropped during the middle. Ceren started the process with the highest affective competence. Her motivation, which was medium, did not improve. Sema started with the lowest levels, but progressed significantly in all aspects excluding self-confidence. In general, the levels of the experienced teachers were lower at the beginning and their progress at the end was greater. The teachers' developments are described separately below.

Descriptive analysis was performed on data from interviews, student focus groups, and the researcher diary to detect factors that influenced teachers affectively at the beginning of a new application.

Case 1: Murat

The teacher's affective features were defined, changes were observed over time, and their reasons were explained.

Murat, who defined himself as energetic, talkative, and innovative in interviews, is thus described in the researcher diary:

> *As I see, Teacher Murat's very energetic. It's impossible to see him sit quietly. Even in the breaks, he's busy fixing something somewhere at school. However, he's anxious about the process. I think it's because he refrains from me. It's obvious he connects well with his circle, but he has trouble communicating with new people, as I remember from training. He's introverted as well as talkative. (Researcher Diary, Week 1)*

As aforementioned, Murat, like many others, has difficulty adapting to new people, which causes his anxiety. He emphasized his positive attitude toward science as follows:

> *"…I love science; it's like a part of my life…" (Teacher Murat, pre-interview)*

He explained his interest, stating that he used science in daily life:

> *"…well, as I told you at first about the board… it's somewhat related to physics subject matter, but I learned roughly how to do it by experimenting… in fact, there's a pulley in class…" (Teacher Murat, pre-interview)*

Teacher Murat's interest in science is expressed with these notes:

> *…On the teacher's desk, there are as many screwdrivers as there are pens. When I first saw the desk, the mess and variety of materials scared me... Students are used to the situation. Sometimes he cannot find something; students find it and give it to him. He's like a repairman who is always ready. Is the desk leg loose? Where should the balance be? Well, a nut here… a screw… students on one side, teacher on the other… problem's solved… (Researcher Diary, Week 2)*

This tendency to solve problems can be related to his impatience. The important thing is that his solutions generally involve scientific concepts. Balance, center of gravity, field measurement, inferences etc., indicate his interest and skill in scientific processes. Even if he had not continued his education in science, he would not have lost interest. To quote him, science is "life itself."

Murat stated in the pre-interview that his students also like science. When the students compared their science lessons from the previous year with this year in the focus group interviews, they indicated that they enjoyed the latter more. Along with the students' increased positive attitudes, Murat's attitude changed as well:

> *…I used to like science, but sometimes I found it difficult… bring materials, experiment, etc. To be honest, I see it differently now. It's no longer difficult because now I think beforehand and design the lesson in my mind. Then, bring the materials, ask the question, and sit back (chuckles)… (Teacher Murat, post-interview)*

Murat was demotivated about lesson requirements despite his positive attitude and overcame the problem during the process. Although he expressed it saying, "I provide materials, leave them the rest," the effect of the process on his progress can be comprehensively examined from observations of learning-teaching objectives.

Murat had a positive attitude toward science teaching and stated in the pre-interview that he felt competent and confident. Later, he emphasized that training tested this competence, and he felt inadequate at the beginning.

> *"…at first, I pontificated… then I realized I didn't know much. I was super demoralized. I intended to put a good face on, but in the initial weeks, I watched you morosely..." (Teacher Murat, post-interview)*

Murat's doubts started with the awareness of new learning, which, like all change processes, caused affective problems at the beginning. If the adaptation findings are ignored, Murat's interest, attitude, motivation, and self-confidence increased continuously throughout the process.

Case 2: Ceren

The sincerity of Ceren, who defined herself as calm, sincere, and open to learning, was emphasized by the researcher as follows:

> *I've known Teacher Ceren for a long time, so we met at a café to avoid formality and had a friendly interview. I didn't have to break the ice as I did with others. I remember the first time I met her; it was also quite warm. She's really sincere. (Researcher Diary, Week 1)*

As aforementioned, the teacher and researcher were acquainted before application, and the researcher mentioned her sincerity even in the first meeting. Her positive attitude toward teaching and science was expressed in the pre-interview:

> *"…Teaching was my dream job; I teach with pleasure and happiness. I love children; I love teaching, so I chose it. My family always supported me. Although I loved and studied science at high school, I preferred teaching." (Teacher Ceren, pre-interview)*

Ceren was highly self-confident in science and stated her views regarding the relevance of science in daily life in the pre-interview:

> *"…Science is the easiest lesson to learn and teach. It's from life; fun, easy to understand, exciting… students enjoy it the most…" (Teacher Ceren, pre-interview)*

Ceren was interested and highly self-confident in science. She emphasized that she never had any mental problems with teaching or preparing lessons. She preferred science education in high school, which indicated her affective competence in the field. She also highlighted the students' willingness to participate in science lessons:

> *"… I teach with pleasure because I really love science. I think students also love it the most…" (Teacher Ceren, pre-interview)*

The teacher and students with highly positive attitudes toward science expressed pleasure in performing science as follows:

> *…well, we sometimes did experiments; we also watched them on "morpa kampus" (an educational e-platform in Turkey), and we loved it. Now we enjoy doing what we watched throughout the semester. No need to watch; we did it. And we did it splendidly! (Teacher Ceren, post-interview)*

> *"…It made me happy to watch and think. Now I'm also excited while trying. I wonder if my idea's right. I pay more attention and find the answer. Aw, look, I'm thrilled again!" (St4, focus group interview)*

Findings from the focus group interview indicated an increase in positive attitude. This was also clear because 96% of answers to "What's your favorite lesson?" were "Science."

The positive attitudes of the students and teacher could not sufficiently motivate Ceren in preparing lesson plans. Ceren took longer to pass the realization stage. The teacher with average motivation at the beginning was unable to progress adequately, which attracted the researcher's attention, and it was mentioned in the semester-break interview. Her lack of motivation was caused by the responsibilities of daily life. She had three sons, and the younger ones were twins. She expressed the situation as follows:

…I can be more patient with my family and kids thanks to the extraordinary patience my job provides. It can sometimes be a disadvantage. There are times I cannot show patience at home, as I got through it at school. And, I sometimes behave like a teacher at home, forgetting my motherhood. It needs balance. But, things can get hectic. We get tired at school, at home… Teaching's really beautiful, but also really hard… (Teacher Ceren, semester-break interview)

Lack of motivation did not adversely affect her instruction. She emphasized it as:

…important thing here is to elude from your inner world, whatever happens. It's over when you're at the classroom door. It has to be… You need to enter as a teacher. Every responsibility will stay out of the door… (Teacher Ceren, semester-break interview)

Her statements indicated that the teacher could leave her personal problems at the classroom door. In the post-interview, she expressed excitement about preparing the lesson and enthusiasm about entering the class, which is considered development.

Ceren's high self-confidence reduced during the process. She stated:

…yes, I said I love science and teaching it. Students understand; their grades are good. I know how to teach, but starting this inquiry-based teaching worried me. We practiced it in training, but… I don't know. I was afraid of what to do, how to do it… and the initial weeks, I did a mediocre job… (Teacher Ceren, semester-break interview)

As Ceren received positive student feedback during the process, her self-confidence increased, and she said:

"…after Mehmet, I said, 'Okay. It's happening…'" (Teacher Ceren, semester-break interview)

Mehmet's case also attracted the researcher's attention, and appeared in the diary notes:

Today, Mehmet, mischievous boy of the class, did wonders in the lesson. He participated in the activity without disrupting the class. I never presumed he would get used to the process like this. His teacher told us about his family problems. His parents don't know how their relationship reflects on him. As he witnesses and considers it normal, he behaves badly with girls. He uses bad language consistently, and he thinks that's normal. The teacher's tired of the situation. She was attracted by his eager participation… (Researcher Diary, Week 10)

Considering the adaptation findings, her affective development increased the least. Her adequate self-confidence, attitude and interest, and average motivation were embraced more at the end of the semester.

Case 3: Sema

According to the researcher, Sema, who defined herself as cheerful and young at heart, was easy-going, talkative, and energetic. She emphasized her love for learning and teaching:

> *"…I love dealing with them. Kids are innocent; parents sometimes give trouble… even if I won the lottery, I'd keep teaching for pleasure…" (Teacher Sema, pre-interview)*

She stated that she was a successful student and got into a science high school. However, her father wanted her to study close by, so she studied mathematics at a county high school. However, she studied French language education at university to become an interpreter. After graduation, she started working as a primary school teacher and continued. Due to a teacher shortage in the past, any university graduate in Turkey was provided the opportunity to become a primary school teacher after taking short-term courses.

Sema, with a highly positive attitude toward teaching, considered it a good job to do for years despite the workload:

> *"…Primary school teaching's good; I've never got bored for years… I can work longer with pleasure. Working hours are good, but we take work home…" (Teacher Sema, pre-interview)*

When asked about her attitude toward science, she stated:

> *"I like science. We try some things, we watch… Students are very interested…" (Teacher Sema, pre-interview)*

Her statements were insufficient to consider her attitude positive. The researcher observed that she lost interest and answered science-related questions vaguely:

> *"She said she loves science, but even her voice was different. I think her attitude's not that positive. We didn't talk much about this. The conversation subsided when science was the subject…" (Researcher Diary, Week 1)*

When questioned about the role of science in her daily life to determine her interest, she said:

> *"I surely use it, but I cannot think of anything now…" (Teacher Sema, pre- interview)*

The researcher attributed this to interview stress and provided five daily life examples for her to explain scientifically, but she could provide only one example.

She was not informed about this before application to avoid uneasiness. After adaptation, she was questioned retrospectively during the semester-break interview. She indicated that she realized her applications were too ordinary; she had self-confidence issues and her motivation decreased. However, she was relieved after she adapted rapidly to inquiry-based teaching.

The researcher cited that the teacher embraced the new application with positive student feedback:

> *This week, I intentionally left the teacher alone for the first time. I had time, but I waited outside. She recorded the lesson. I haven't watched it yet, but she said, "It wasn't like a lesson. We made hot chocolate and drank it. I don't think they learned something…" (Researcher Diary, Week 9)*

Her not considering it a lesson because she taught differently was an affective barrier. She did not follow her method, which disturbed her and made her feel like she had shirked her job. Upon realizing this, the researcher administered an achievement test to the students. Everyone overachieved, which surprised their teacher and increased her motivation and interest quickly.

Inquiry-based science teaching applications decreased Sema's affective barriers substantially, beginning with her belief in the process. Her students' success also helped decrease her barriers.

Sema's motivation was low, and her interest, attitude, and self-confidence in science were medium at the beginning. After adaptation, she overcame her prejudices and her interest and attitude improved rapidly, which, along with student feedback, increased her motivation during the progress step. However, she had limited progress in self-confidence.

The Effect of the Professional Development Program for Inquiry-Based Science Teaching on Primary School Teachers' Communicative Barriers

Communicative barriers were organized under two sub-themes: communication and interaction. Teachers' communicative approaches and discourse patterns revealed their communicative barriers. Table 6 presents the changes in these barriers with the program steps.

Table 6. Change in Communicative Barriers during the Program

		Communicative Barriers	
Program steps	**Teacher**	**Communicative approach**	**Discourse pattern**
Introduction, Adaptation	Murat	Authoritative Interactive/ Noninteractive	Triadic
	Ceren	Authoritative Interactive/ Noninteractive	Triadic
	Sema	Authoritative Interactive/Dialogical Noninteractive	Triadic
Realization, Change, Progress	Murat	Dialogical Interactive/ Noninteractive	Triadic/Chain
	Ceren	Dialogical Noninteractive	Triadic/Chain
	Sema	Dialogical Interactive/ Noninteractive	Triadic/ Chain
Reinforcement	Murat	Dialogical Interactive	Chain
	Ceren	Dialogical Interactive	Triadic/Chain
	Sema	Dialogical Interactive	Chain

Table 6 reveals that each teacher used teacher-centered authoritative structures. Murat and Sema, both experienced teachers, could turn authoritative into dialogical, while Ceren improved her authoritativeness only in interaction. Regarding discourse patterns, each teacher's triadic pattern (initiation-response-feedback) attracted attention. All three progressed in this dimension and started using chains (initiation-response-feedback-response-feedback). In the end, Murat and Sema discarded triadic structures in teaching, while Ceren used them infrequently.

Case 1: Murat

Murat emphasized using within-class communications effectively to describe his students:

> *…because the kid glances away when asked questions; that means he didn't learn. If a student learns, he looks you in the eye. I don't know… he expects compliments, applause, or warm behavior. But, if he doesn't learn, he looks at the ground. I know because we did it, too (laughs)… (Teacher Murat, pre- interview)*

He emphasized his authoritative, disciplined nature in interactions. He believed class has an order and rules.

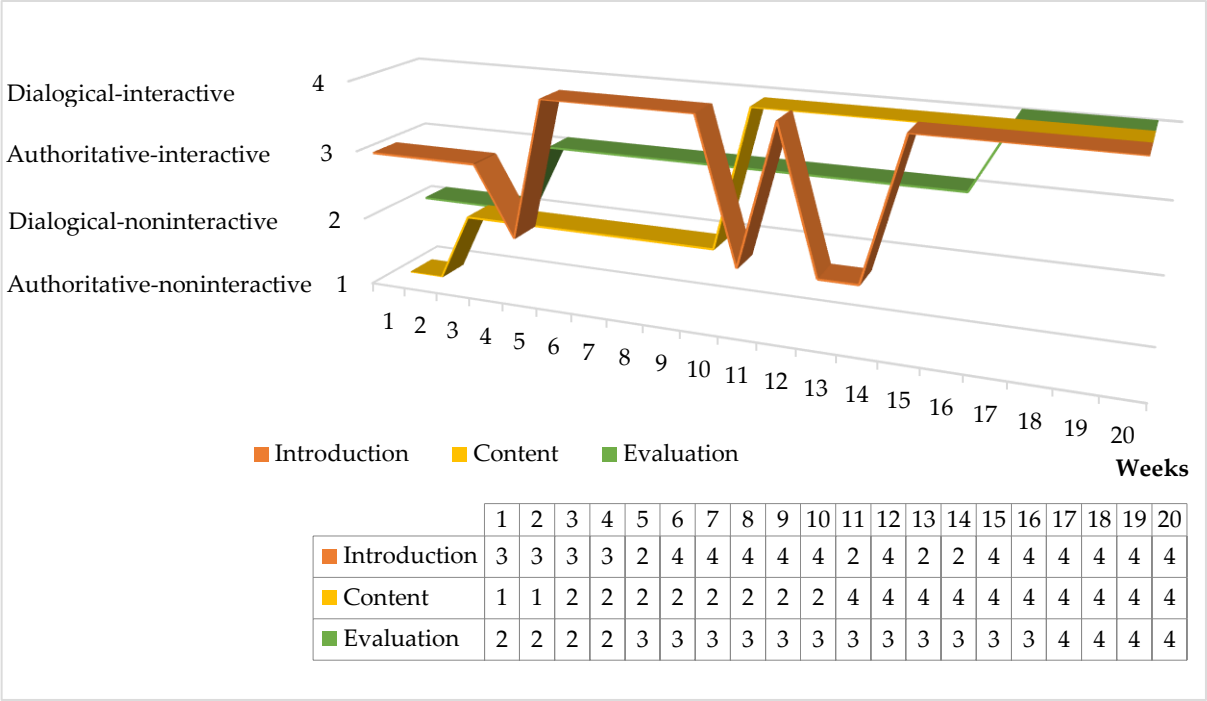
> *…Discipline! Ease? No! For example, in maths, they should be as quiet as mice for the first 10 minutes; it's very important. We'll have the lesson together. I don't go to the board and say, "Watch me." We'll solve questions together. I'll save these kids. Well, those 10 minutes are important! (Teacher Murat, pre-interview)*

Murat wanted to attract his students' attention with discipline. Students behaved freely except for specified times:

> *As I understood, the teacher's comfortable in classroom management. He's against routine. His classroom environment and communication are quite comfortable. He's even against the cupboard in class. He has an order for shelves, and wants everything at hand. He's too restless. He calls himself "fuss master." Two students resemble him; he calls them fuss principal and vice-principal. Fuss principal is a one-armed disabled student. He trained students so comfortably that they behave as they wish but not improperly. They can go out and walk around during the lesson if they need. (Researcher Diary, Week 1)*

He wanted to be considered strict, though. He grumbled loudly when students behaved improperly in corridors. However, the students wanted to hug him whenever possible. He was a strict, affectionate teacher.

His communicative approach was observed throughout the process. The findings are presented in Figure 3. The graph shows the entire 20-week process for holistic comprehension.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Introduction	3	3	3	3	2	4	4	4	4	4	2	4	2	2	4	4	4	4	4	4
Content	1	1	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4
Evaluation	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4

Figure 3. Change in Murat's communicative approach

The teachers' communicative approach was monitored separately, although presented together to ensure chart integrity. Since it is possible to use different approaches in different parts of a lesson, it was examined in three divisions, introduction, content, and evaluation. The teacher used authoritative structures during the first two weeks. Murat, who mastered the process in 10 weeks, started using interactive structures. Upon mastering planning in 16 weeks, he started using the dialogical-interactive model, in which the teacher values each student's opinion and includes the students in the dialogue. Murat's approach was authoritative-noninteractive at the beginning of evaluation; it became interactive later in the process. He emphasized during interviews that he was unable to adopt it because the process was extremely noisy. Indeed, in the inquiry-based approach, in which groups are busy learning independently, a productive noise is natural in class. However, it was considered a threat by Murat, who had authoritatively maintained control of the class for years. He indicated in the post-interview that he still desired to maintain control when the lesson ended. He finally defined this threat to authority as unnecessary at week 17 and could use the interactive approach during the last three weeks.

Along with the communicative approach, the teacher's within-class discourse types also changed. The process and discourse patterns are presented in Tables 7 and 8.

Table 7. Triadic Pattern Sample Transcript (Week 5, Unit: What is Matter, Teacher: Murat)

Participant	Transcript	Discourse type	Pattern
Teacher	How many states of matter are there, kids?	Initiation	Triadic
Enes	Three.	Response	
Teacher	That's right. What are they?	Feedback	
Merve	Solid-Liquid-Gas.	Response	
Kaan	Solid-Liquid-Gas.	Response	
Teacher	That's right.	Feedback	

This initiation-response-feedback dialogue was triadic and involved superficial interaction. It was not continued, and a new dialogue was established with another question. Triadic dialogues lack student-student interaction. Teachers respond to each answer with feedback, preventing students from enjoying communication, like practicing tennis against a wall. Table 8 presents a sample chain pattern within-class dialogue initiated by Murat.

Table 8. Chain Pattern Sample Transcript (Week 11, Unit: Light and Sound Technologies from Past to Present, Teacher: Murat)

Participant	Transcript	Discourse type	Pattern
Teacher	You know who invented the light bulb, right?	Initiation	Chain
Enes	Edison.	Response	
Teacher	When?	Feedback	
Merve	1900.	Response	
Kaan	1970.	Response	
Teacher	There were even computers in 1970. I think it was earlier. When could it be?	Feedback	
Koray	1937.	Response	
Can	1872.		
Teacher	1800s.	Feedback	
Koray	Yes, teacher.	Response	
Teacher	Well, in short, toward the end of the 1800s. If I build a time machine and take you to 1850…	Feedback	
Can	Ooo… (chuckles)	Response	
Teacher	Don't say so! (gets angry) We are in 1850; what time does it get dark?	Feedback	
Beyza	7.30-6.30.	Response	
Teacher	About 7.30.	Feedback	
Ayla	1872! (answers from book excitedly) (teacher nods)	Response	
Teacher	There's no light bulb; everywhere is dark. You go home, it's dark. Your parents aren't home. You wonder where they are. You need to find them, but how?	Feedback	
Beyza	Fire!	Response	
Koray	Gas lamp.	Response	
Teacher	What else?	Feedback	

Here, the teacher does not suspend communication, but instead elaborates student answers by reflecting on them and directs the dialogue. Consequently, within-class dialogues improved; students began using interactive structures more comfortably.

Murat started with the authoritative approach and completed the process dialogically. He used the triadic pattern in the introduction and adaptation stages, gradually transitioned to chains, and discarded triadic structures completely at the end. By improving slowly and steadily, he adopted student-centered communicative approaches.

Case 2: Ceren

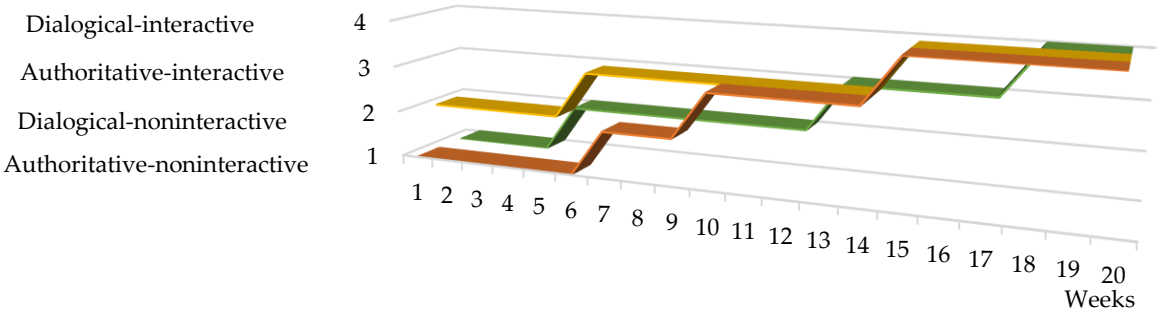
Ceren emphasized that within-class interactions affected learning, and the teacher-student and student-student interactions in her class were good:

> *"I communicate with students comfortably because I love my job and my kids, and it affects them, of course. They also feel at ease; we're open to learning from each other. We interact quite comfortably in class…" (Teacher Ceren, pre-interview)*

Ceren highlighted the dominance of the interactive approach in class, but indicated the opposite when speaking about discipline. She had an authoritative attitude, defining class as a place with rules imposed by the teacher, and believing that the teacher should maintain order.

> *Class order's very different from the others. The teacher's quite disciplined. Her class is fun, but everyone's aware of the rules. She has the advantage of educating the same students since grade 1. However, I feel authority as well as order. The teacher's the leader. It helped me in the first lesson; class management was easier, but I have concerns about the interactive approach. (Researcher Diary, Week 1)*

Communication-related findings from weekly observation forms are presented in Figure 4. The chart includes the entire 20-week process for holistic comprehension.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Introduction	1	1	1	1	1	1	2	2	2	3	3	3	3	3	4	4	4	4	4	4
Content	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4
Evaluation	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	4	4	4

Figure 4. Change in Ceren's communicative approach

Initially, the teacher used a noninteractive approach in lessons, so the researcher taught them for five weeks. When the teacher's teaching was examined from week 6, an authoritative-noninteractive approach was found to be dominant in the introduction part of the lesson. The teacher was informed of this in meetings before and after lessons.

> *The teacher adopted an authoritative approach in the introduction part of the lessons for weeks. I thought it's due to lack of motivation. I broached the subject with her this week. She said she wanted to review the previous lesson first, and she felt obliged to narrate everything she knew. As she's in a rush to cover everything, she excludes students. We determined some solution-oriented tactics for the following weeks. (Researcher Diary, Week 6)*

Ensuring students' active role in the introduction of the lesson changed communication from noninteractive to interactive. Other parts of the lesson gradually improved as well. Ceren could transition from authoritative-noninteractive to dialogical-noninteractive, authoritative-interactive, and dialogical-interactive successively. The content part of lesson improved most easily, while progress was hardest in the evaluation part because Ceren's narrative nature dominated evaluation, but abated in the content part. She started allowing the students authority only in the evaluation part of the lesson. Inquiry-based applications also changed her discourse patterns, presented in Tables 9 and 10.

Table 9. Pattern Sample Transcript (Week 5, Unit: What is Matter, Teacher: Ceren)

Participant	Transcript	Discourse type	Pattern
Teacher	We know there are three states of matter. Who will give examples?	Initiation	Triadic
Students	Me… Me!	Response	
Teacher	Raise your hand. Yes, Mehmet?	Feedback	
Mehmet	Solid-Liquid-Gas.	Response	
Teacher	What did I say? Example, example…	Feedback	
Mehmet	Teacher, well…	Response	
Teacher	Okay, Mehmet, sit down. Rumeysa?	Feedback	
Rumeysa	Solid… Wood, teacher. Liquid...	Response	
Teacher	Okay, sit down. And you, dear? Liquid?	Feedback	

The discourse of the dialogue is triadic and authoritative. The teacher controlled the students' speech and afforded them no opportunity to clarify their answers. Students considered expressions like "Okay, sit down!" feedback, which affected them adversely as their response was incomplete. In this noninteractive structure, students cannot communicate with each other, which strengthens the teacher's authority. This changed when Ceren discarded authoritative structures. Table 10 presents a sample of her using the chain pattern in dialogue.

Table 10. Chain Pattern Sample Transcript (Week 16, Unit: Microscopic Creatures and Environment, Teacher: Ceren)

Participant	Transcript	Discourse type	Pattern
Teacher	Why does oil float on water?	Initiation	Chain
Yusuf	Well, because it's oily.	Response	
Teacher	Why is it on top?	Feedback	
Ayse	Because its oil is too much.	Response	
Teacher	If there's less oil, it won't float?	Feedback	
Mehmet	It will.	Response	
Teacher	We're trying to dissolve it, but as you see, oil floats. Why?	Feedback	
Yusuf	Because it's fluid.	Response	
Teacher	Well, [does] any fluid float?	Feedback	
Yusuf	Olive oil.	Response	
Teacher	Only oil? Why does plastic float?	Feedback	
Ayse	There's air inside.	Response	
Teacher	Okay, it has air. What about oil?	Feedback	
Mehmet	It's light.	Response	
Teacher	Is oil light? For example, I put 3 liters of water and 5 liters of oil. It floats? Yes or no?	Feedback	
Students	No.	Response	
Teacher	Why not?	Feedback	
Ayse	It's heavier.	Response	
Teacher	What makes it float? Air? If you throw a stone inside?	Feedback	
Students	It sinks.	Response	
Teacher	What about wet wipes?	Feedback	
Students	It floats.	Response	
Teacher	Why?	Feedback	
Mehmet	Matter, teacher.	Response	
Teacher	Only matter floats? Objects cannot? What about this?	Feedback	
Students	It floats.	Response	
Ayse	If we fill it with water…	Response	
Teacher	Think about the question. What about liquid soap?	Feedback	

This 138-second dialogue at week 16 demonstrates an interactive approach. It was noteworthy that Ceren did not interrupt the students, but guided them. She reflected with new questions, during which she made eye contact and encouraged students to respond with her gestures.

> *Compared to others, she uses her body language effectively. She looks at the student intending to disrupt the lesson, swinging amazingly fast with her whole body; everything comes right. Or, she uses her hands, arms, and even eyes to address a question to a student. Kids are used to this. They never mistake who is to speak. This situation's also because of the space in class. For instance, in Teacher Sema's class, it's impossible to come between students. Teacher Ceren's lucky, and uses it well… (Researcher Diary, Week 16)*

In the introduction and adaptation steps of the program, Ceren used authoritative structures in a triadic pattern. She started using dialogical structures in the realization, change, and progress steps, but maintained its noninteractive nature. It is noteworthy that she could use interactive structures in the process she started with an authoritative approach, but could not maintain a dialogical discourse. It shows her struggle in changing her communicative approach. At the end of the process, she could adopt dialogical-interactive structures like the other teachers. However, she could not completely change her discourse pattern to a chain structure and continued using triadic structures occasionally. Ceren found it the hardest to change her communication and changed the least, which can be related to her having the highest affective level at the beginning. It took her the longest to realize and embrace her deficiencies.

Case 3: Sema

Sema was the most antagonistic participant in the program. Her communicative approach prevented her from accepting the researcher not answering certain questions and directing them with new questions in the training. During training, Sema objected frequently:

> *"…It's not possible in my class. These kids are used to answers. They ask, I answer. I ask, they answer. My kids get bored; I need to tell them immediately what I will teach…" (Teacher Sema, pre-interview)*

Sema believed that her students were used to triadic interaction, and that changing it would cause problems. She felt apprehensive because she realized that inquiry-based science teaching was not conducive to it. It was considered a reaction to change, and her progress was observed without interference.

When asked about class interaction and teacher communication, she said:

> *"…well, I have many smart students. And a few… let's say bottom and top… those at the top are more individualistic. As they're idealist, they want to distinguish themselves. They're in competition. For example, one student always gets 100; when someone gets 98, he belittles them. I don't want them to talk among themselves, but they instantly do. I don't want a silent class; indeed, they should speak their mind. I sometimes punish, but never humiliate them…" (Teacher Sema, pre- interview)*

The researcher claimed that the problems were actually based on miscommunication in class:

> *…We made class arrangements for group work. Classroom's too small. There's no laboratory. You cannot walk between desks. It's a miracle the oxygen here is enough for them. I wanted students to sit together to fit groups into the classroom. Nobody agreed. Total chaos... Students are extremely selfish. They acquiesced not to hurt me, but they sulked. When they needed to experiment together, they did it whining… (Researcher Diary, Week 2)*

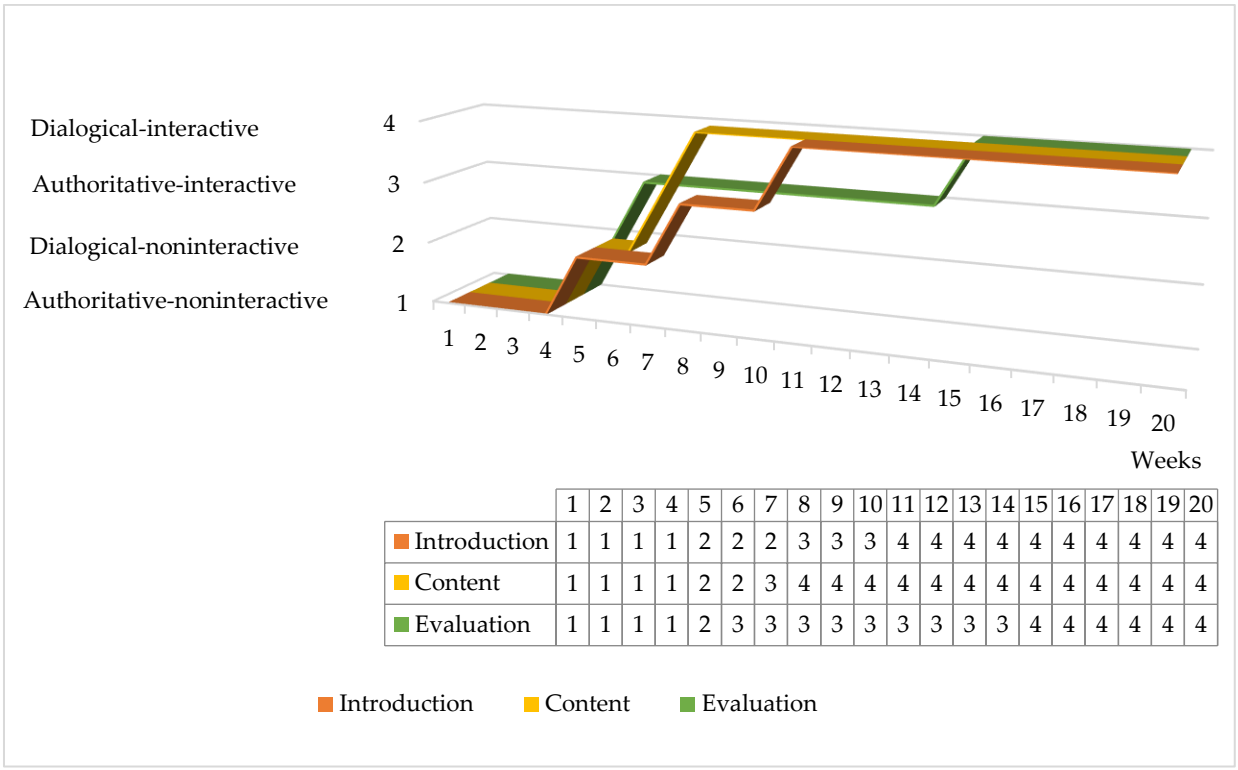
Miscommunication in the class interested the researcher, who spoke about it with the teacher and noted:

> *…We spoke about the situation with the teacher, who thinks it's because of parents. She said, "Mothers made complaints like 'You cannot make my kid sit with her kid.' Even kids keep their distance saying that their mothers will get angry." I said I wanted to solve this; she said it would become a problem. I showed her approval forms I took from parents before application, and gave their copies to her to show the parents if they objected to groups… (Week 3, Researcher Diary)*

The researcher suggested some games to the teacher to strengthen communication. They were not observed, but the teacher highlighted their effectiveness:

> *…That knot game… (laughs)… What a fight it was! You hold him, you hold her… I said, "Oh, no! There's a fight tonight in the parents' group." The game began. They lost themselves. "We should untie first. My dear friend… be quick… you're great!" etc. They fancied it. I waited for calls or messages that night, but nothing… These kids are astute… (Teacher Sema, semester-break interview)*

Sema's attempts to resolve communication problems helped her with classroom management and enhanced peer learning. Figure 5 presents relevant findings from weekly observation forms.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Introduction	1	1	1	1	2	2	2	3	3	3	4	4	4	4	4	4	4	4	4	4
Content	1	1	1	1	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4
Evaluation	1	1	1	1	2	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4

Figure 5. Change in Sema's communicative approach

Sema used an authoritative-noninteractive approach for four weeks. She tried to accustom students to the process in her way; the researcher observed her without interfering to identify her approach. She discarded authoritative-noninteractive structures in week 5 and adopted a dialogical-noninteractive approach, except for in the evaluation phase. She attempted interaction in it to control meaningful learning, but proceeded authoritatively because of classroom management problems. The teacher's authoritative interaction attempts were noted as follows:

> *"…The teacher uses a whistle to silence the class. I heard it this week for the first time; I was startled. The whole class laughed at me. They're used to it…" (Researcher Diary, Week 5)*

Sema started the process in a dialogical-noninteractive manner in introduction and transitioned to authoritative-interactive at week 8. The researcher detected a dialogical-noninteractive approach at week 5 and provided on-the-job support at week 6; Sema started using interactive structures in three weeks. The gradual progress culminated in the dialogical-interactive approach at week 11, with help from the semester-break meeting. The teacher indicated her awareness of the situation at week 10:

> *"…Actually, they don't exactly talk to each other, right? I'm aware of it; I interrupt constantly. I'm afraid there'll be a mess if I don't give the floor…" (Teacher Sema, semester-break interview)*

Sema progressed fastest in the content part of the lesson, in which she adapted to applications easily. In the first four weeks, classroom management and communication problems were addressed, which were teacher-based. Since she conducted lessons with students who liked responsibilities, it boosted their self-confidence and demotivated others. The researcher claimed that self-confident students scorned others at every opportunity.

> *…The teacher's classroom management is different. The responsibilities she gave were fulfilled. However, the responsible group proved themselves and did everything in class. It seems as if there's no problem. Making silent students speak is difficult here because whenever they respond to me, someone scorns them. Today, I asked a mocking student for his opinion to suppress him; he responded immediately. I asked an unexpected question; he was upset not to answer, but I saw the mocked student smiling. Even if it's a bit cruel, I'll do this to stop mocking… (Researcher Diary, Week 3)*

The researcher aimed to strengthen peer communication first to enhance within-class interaction to facilitate the teacher's interaction with students. It is understood from the group's immediate response to the researcher's application that the teacher's behaviors caused the situation. When the researcher guided them, the students were busy with questioning and stopped criticizing each other cruelly.

> *…This week, nobody scorned anyone. I guess everyone is used to all opinions. That I care for every response from the suppressed group silenced the mocking ones and encouraged the silent ones. Actually, the teacher allows everyone who wants to speak, but they don't even want to request. Thirty students… high-level ones are always active. The teacher barely serves them. When I told her this, she said she could not keep up. I suggested she ask brain-twisters to high-level students. She said the kids were already busy with this method while satisfying their curiosity. She will also accept it… (Researcher Diary, Week 4)*

The teacher tried these suggestions and surprised the active students she cherished.

> *…The teacher didn't answer a high-level student's question this time and addressed it to another student. The kid was stupefied to get no response. However, they formulated opinions well and made observations as a group. That they took notes attentively was nice. Then, they made inferences and discussed with others. Everyone talked. Groups visited each other and watched presentations this week. They felt like hosts. Dialogues between groups were good… (Researcher Diary, Week 5)*

In the content phase, Sema transitioned from dialogical-noninteractive to dialogical-interactive during week 6 after realizing the class had no objection. Interactive communication directly affected the within-class discourse pattern. During week 5, noninteractive class discourse was generally triadic. A sample interaction is presented in Table 11.

Table 11. Triadic Pattern Sample Transcript (Week 5, Unit: What is Matter, Teacher: Sema)

Participant	Transcript	Discourse type	Pattern
Teacher	What's the solid state of water?	Initiation	Triadic
Yusuf	Hail.	Response	
Teacher	No way.	Feedback	
Students	(Laughing) No!	Feedback	
Teacher	You tell me, Berk.	Initiation	
Berk	Of course. Ice.	Response	
Teacher	That's right.	Feedback	

The discourse starts with a question and continues with feedback for each answer. Line 3, the teacher's feedback of "No way" enables students to join in the feedback and mock their peers. This process hinders within-class interaction and prevents peer learning. Students competing among themselves are not busy questioning. One reason is that the teacher does not compel students cognitively. When the teacher realized that intervention to enhance students' communication worked, and that she could establish dialogues between students, she started to reflect responses and students' interaction increased. Instead of judging others' opinions, students listened to each other to comment.

> *…Students' attempts to see each other while talking attracted my attention this week. When the teacher directed a student's answer to another, he addressed his friend, and the one who answered leaned to see her friend. They started to speak regarding each other. It's wonderful progress. Nobody cared before… (Researcher Diary, Week 8)*

Sema's attempt to establish dialogues authoritatively led to the noninteractive approach. Changing it and freeing students ensured in-class interaction in the chain pattern. A sample is presented in Table 12.

Table 12. Chain Pattern Sample Transcript (Week 11, Unit: Light and Sound Technologies from Past to Present, Teacher: Sema)

Participant	Transcript	Discourse type	Pattern
Teacher	How does sound travel?	Initiation	Chain
Yusuf	Waving.	Response	
Teacher	Like a water wave?	Feedback	
Students	Yes.	Response	
Teacher	Is it like surging?	Feedback	
Berk	We can't see.	Response	
Teacher	I see sea waves.	Feedback	
Students	Yes.	Response	
Teacher	Well, let's say waves in the air. What about over land?	Feedback	
Yusuf	Vibration.	Response	
Teacher	How? Can I feel it?	Feedback	
Sule	Yes.	Response	
Tugce	How can you feel? It's not hearing!	Response	
Berk	I know it's not!	Response	
Tugce	Show it, then.	Response	
Sule	(hits the table and vibrates what's on it) Look!	Response	
Cansu	It's the intensity of hitting.	Response	
Berk	Sound has an intensity.	Response	
Tugce	Yeah, well… but how will you show it?	Response	
Teacher	You say you see the effect of hitting. What if we don't touch?	Feedback	
Orhan	Right, I never touch.	Response	
Goktug	Teacher, let's play sound.	Response	
Teacher	On the computer?	Response	
Goktug	Yes, we have speakers.	Response	
Teacher	All right, come and play.	Feedback	
Orhan	Let's play "Night shadows."	Response	
Yusuf	Yeah!	Response	
Teacher	Okay, whatever you want.	Response	
Orhan	But, let's put something in front of the speakers.	Response	
Tugce	Pencil? No! Put something light.	Response	

Here, Sema intervenes in the process only when she finds it necessary. The conversation is mostly among students. Sema, who used to use a whistle to stop dialogues, intervened only when she was disturbed by the volume at the end of activity.

Only Sema used dialogical, albeit noninteractive, structures at the beginning, which helped her pass the realization step faster. She used the chain pattern in dialogical structures at the end of the process.

Discussion and Conclusion

In this study to observe change in teacher barriers during a professional development program, internal barriers against novelty were first identified, then monitored throughout the process. Barriers identified through interviews and observation forms were categorized under two main themes; affective and communicative barriers. The affective domain comprised barriers related to interest, attitude, motivation, and self-confidence. Teachers' interest and attitude affected their motivation and self-confidence, which built barriers against novelty. Previous literature has also proved that teachers' affective state influences their within-class behaviors (Anderson, 2002; Anderson & Helms, 2001; Gaines et al., 2019; Johnson, 2006; Kielborn & Gilmer, 1999; Soysal & Tanik, 2017; Yoon & Kim, 2010).

Affective Barriers

Considering each teacher's affective state, Sema was the most resistant to the process at the beginning. She started the process with low motivation. Her school was centrally located and crowded; she felt pressured by management and parents, and pressure is known to affect motivation (Anderson, 1996, 2002; Anderson & Helms, 2001; Soysal, Tanik, & Tunali, 2019). Additionally, her not studying primary school teaching may have caused her timidity. Ceren was the youngest and the only one with a bachelor's degree in primary school teaching. Therefore, she approached the process more confidently. Sadler (2013) discovered that teachers are more confident about teaching if they believe in their field knowledge. Research has also indicated that individuals are more self-confident in the field they have studied and mastered (Appleton, 1995). In his study, Dikilitaş (2013) observed the effects of teacher education on teachers' beliefs and in-class practices, and emphasized that a change in teachers' beliefs occurred after the training and was maintained six months later.

It is notable that Murat and Ceren, who started with high motivation, lost some motivation in the realization, change, and progress steps. It may be because individuals who consider themselves competent realize their deficiencies with a new application and get anxious about managing with it. Appleton and Kindt (1999) stated that teachers with inadequate field knowledge have low self-confidence. Martin and Lueckenhausen (2005) proposed that teachers dislike feeling inadequate in front of their students. It is natural for teachers with low self-confidence to lack motivation. In this study, teachers realizing their deficiencies lost some self-confidence and motivation. Through the process, however, because teachers saw that they could manage the application and that it affected students positively, their interest, attitude, motivation, and self-confidence levels increased. Studies have demonstrated that student reactions play an important role in teachers' adopting a method (Gess-Newsome et al., 2019; Guskey, 2002; Loucks-Horsley et al., 1998).

Borg (2011) observed a differentiation rather than a change in teachers' beliefs following eight-week in-service training conducted with English teachers because beliefs about teaching are considered as subjective and difficult to measure and can only be assessed with the expressions of individuals. Lamie (2004) identified a differentiation in the attitudes and practices of teachers after in-service training, but no change in their attitudes toward teaching. Although the effects of affective barriers on teachers and students are undeniable, which are attempted to be explained through indirect inferences, it is possible to discuss with different ideas.

Communicative Barriers

Communicative barriers were investigated in two dimensions, namely, communication and interaction. Teachers' existing barriers prevented them from adopting new applications. The gradual disappearance of these barriers depended on their progress. One's approach changes only when one embraces a new approach to replace it (Nguyen, Haworth, & Hansen, 2019). If there is no differentiation between the approaches, teachers may even discard something about which they are enthusiastic (Briscoe, 1996).

It is noteworthy that each teacher used authoritative structures in communication at the beginning. They were sometimes interactive, but each teacher's discourse pattern was triadic. This indicates that they adopted a teacher-centered approach. Research has confirmed that individuals with a teacher-centered approach interact more authoritatively (Kaya et al., 2016; Mortimer & Scott, 2003). According to Lemke (1990), teachers are unwilling to discard triadic structures because they provide advantages like directing and managing students. Teachers who started using dialogical structures during the realization step could not discard the triadic pattern, although they sometimes utilized the chain pattern. Until the reinforcement step, both triadic and chain patterns were utilized. This lengthy step, which lasted from week 5 to week 18, proves that a long time is required to change teachers' approach (Borko, 2004; Franke et al., 2001). By weeks 19 and 20, each teacher was used to dialogical-interactive structures. Taking into consideration the weekly 3-hour lessons and 1-hour preparation and evaluation, an approximately 80-hour application was conducted with teachers. Change was embraced as late as weeks 19 and 20, which confirms that at least 80 hours of application are required for professional development programs to lead to change (Cohen & Hill, 1998; Loucks-Horsley et al., 1998; Supovitz & Turner, 2000). Although all three teachers preferred the chain pattern during reinforcement, Ceren still used the triadic pattern as well. She found it the hardest to change her communication and changed the least, which may be related to her initially having the highest affective level. It is harder for teachers with high self-confidence to realize their deficiencies.

All three teachers progressed mostly in the communicative domain with on-the-job support. The results indicated that inquiry-based science teaching improves teachers' communication, strengthens interaction, and increases discourse quality when applied properly. Strong interaction skills positively affect students' academic success, attitude (Chin & Kayalvizhi, 2005), interest, motivation (Çevik, 2008), questioning skills, question quality (Chin & Brown, 2000; Günel, Kıngır, & Geban, 2012), scientific process skills (Pillar, Prudente, & Aguja, 2015), and communication skills (Biddulph & Osborne, 1982). These studies show that it is possible to increase within-class interaction by eliminating barriers, which would help students progress in relevant fields.

Spiral Relationship between Affective and Communicative Barriers

When affective and communicative barriers were examined together, it was found that Sema, who was initially less interested and motivated, was the only one to use dialogical structures, even if they were noninteractive. Ceren and Murat, whose affective levels declined, did not show a decrease in their communicative level, possibly because communication is a process between the teacher and students. Teachers adopted student-centered approaches slowly but surely, and did not exhibit teacher-centered behaviors again. Short-term decreases in affective state did not affect their communicative progress. Sadler (2013) determined that interactive approaches could enhance teachers' self-confidence. Similarly, in her study with teachers with low self-confidence, Hativa (2000) concluded that effective communication increased teachers' self-confidence.

As communicative approach becomes interactive and discourse pattern starts using chain structures, continuous progress is achieved, which brings teachers closer to innovative student-centered applications. Student-centered lessons affect teachers' communicative approach (Seedhouse, 2004). An interactive communicative approach influences the affective domain positively, and spiral progress continues.

Each teacher's affective and communicative progress indirectly affected students by increasing positive attitude and improving skills. Chin (2007) and Koc (2006) concluded that teacher-student communication is interactive, students have high-level attitudes toward lessons, and meaningful learning occurs in a constructivist classroom environment. The students emphasized in the post-focus group interviews that the teachers' affective and communicative improvement enhanced their attitudes toward lessons.

The results indicated that teachers expect support to transfer a process they are trained for to their classes. Freeman (2002) emphasized that cognition and behavior are related, but there is no evidence to be seen in practice. In his research with teachers, he determined that not all of the teachers who completed the training reflected what they had just learned in their practices. Gess-Newsome (2001) and Dolfing et al. (2021) stated that teachers find it difficult to leave the familiar and reliable and proceed to the new and indefinite. Teachers seek support to take the first step. Adaptation and initiation with support took four weeks in this study. Expert support for teachers ensured the process would start and continue. The gradual decrease of on-the-job support is explained in terms of scaffolding, as referred to in Vygostky's zone of proximal development (Stone, 1998). Scaffolding is crucial for construction. It is dismantled as the building rises. It is only possible to use scaffolding to develop behavior in individuals through interaction (Ahioglu, 2008). Wood, Bruner, and Ross (1976) explained this as improving learners' existing abilities with expert aid. The important components of scaffolding are working collaboratively, commonizing goals, establishing intimacy, and keeping the learner in the zone of proximal development (Wells, 1999). In line with these components, scaffolding support for teachers was functional, and progress was observed throughout the process. These research results align with those in the literature. Throughout the study, providing support through scaffolding facilitated the teachers' progress and change regardless of their levels (Chin & Osborne, 2008).

It was observed that change occurs if teachers' professional development proceeds with an internal motive. It is only possible to make teachers adopt a new method by eliminating their internal barriers. This study was limited to three teachers, and their barriers were identified. It is also possible to determine different barriers with different groups. Therefore, the main objective of professional development programs should be to know the target group and identify and eliminate their barriers. In this study, the internal barriers to a new application were identified to be interest, attitude, motivation, self-confidence, communicative approach, and discourse patterns. On-the-job support through scaffolding was effective in eliminating these barriers. The nearly 80 hours of support show that change is a lengthy process. It is recommended that teachers' professional development be promoted through long-term models focusing on barriers and including on-the-job support.

Acknowledgments

We gratefully acknowledge the constructive feedback of editors and anonymous reviewers on earlier versions of this paper. We also appreciate the support of Hacettepe Teknokent Technology Transfer Center for advanced editing service to the first draft, and Assoc. Prof. Dr. Yalçın Yalaki and Assoc. Prof. Dr. Asiye Parlak Rakap for proofreading of the final draft of the English version of the paper. Finally, we are thankful to Instructor Dr. Fatma Türkyılmaz for advance editing service to the final draft of the Turkish version of the paper.

References

Academy for Educational Development. (2002). *National writing project: Final evaluation report.* New York: Academy for Educational Development.

Ahioglu, E. N. (2008). Child development within the framework of cultural-historical theory. *Ankara University, Journal of Faculty of Educational Sciences, 41*(1), 163-186.

Ajzen, I. (1991). The theory of planned behavior. *Organization Behaviour and Human Decision Process, 50*, 179-211.

Aldahmash, A. H., Alamri, N. M., & Aljallal, M. A. (2019). Saudi Arabian science and mathematics teachers' attitudes toward integrating STEM in teaching before and after participating in a professional development program. *Cogent Education*, *6*(1), 1580852.

Anderson, R. D. (1996). *Study of curriculum reform.* Washington, DC: U.S. Government Printing Office.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.

Anderson, R. D., & Helms, J. V. (2001). The ideal of standards and the reality of schools: Needed research. *Journal of Research in Science Teaching, 38*(1), 3-16.

Andrews, S. (2007). *Teacher language awareness*. Cambridge and New York: Cambridge University Press.

Appleton, K. (1995). Student teachers' confidence to teach science: is more science knowledge necessary to improve self-confidence?. *International Journal of Science Education*, *17*(3), 357-369.

Appleton, K., & Kindt, I. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education, 21*(2), 155-168.

Barbour, R. (2008). *Doing focus groups.* London: Sage.

Barker, C., & Galasinski, D. (2001). *Cultural studies and discourse analysis. A dialogue on language and identity.* London: Sage.

Bell, L., & Bolam, R. (2010). Teacher professionalism and continuing professional development: Contested concepts and their implications for school leaders. In T. Bush, L. Bell, & D. Middlewood (Eds.), *The principles of educational leadership and management* (pp. 89-111). London: Sage.

Biddulph, F., & Osborne, R. (1982). *Some issues relating to children's questions and explanations* (Working Paper No. 106). New Zealand: University of Waikato.

Borg, S. (2011). The impact of in-service teacher education on language teachers' beliefs. *System, 39*(3), 370-380.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Borko, H., Frykholm, J., Pittman, M., Eiteljorg, E., Nelson, M., Jacobs, J., & Schneider, C. (2005). Preparing teachers to foster algebraic thinking. *Zentralblatt für Didaktik der Mathematik, 37*(1), 43-52.

Briscoe, C. (1996). The teacher as learner: Interpretations from a case study of teacher change. *Journal of Curriculum Studies, 28*(3), 315-329.

Buck, P. (1996). Pitfalls on the road to scientific literacy. In W. Graber, & C. Bolte (Eds.), *Scientific literacy* (pp. 217-232). Kiel, Germany: Institute for Science Education.

Bümen, N., Ateş, A., Çakar, E., Ural, G., & Acar, V. (2012). Türkiye bağlamında öğretmenlerin mesleki gelişimi: sorunlar ve öneriler. *Milli Eğitim Dergisi*, *42*(194), 31-50.

Büyüköztürk, Ş., Akbaba-Altun, S., & Yıldırım, K. (2010). *TALIS: Uluslararası öğretme ve öğrenme araştırması Türkiye ulusal raporu.* Ankara: Milli Eğitim Bakanlığı Dış İlişkiler Genel Müdürlüğü.

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching, 44*(6), 815-843.

Chin, C., & Brown, D. E. (2000). Learning in science: A comparison of deep and surface approaches. *Journal of Research in Science Teaching, 37*(2), 109-138.

Chin, C., & Kayalvizhi, G. (2005). What do pupils think of open science investigations? A study of Singaporean primary 6 pupils. *Educational Research, 47*(1), 107-126.

Chin, C., & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning science. *Studies in Science Education, 44*(1), 1-39.

Cohen, D. K., & Hill, H. C. (1998). *State policy and classroom performance: Mathematics reform in California*. Philadelphia: Consortium for Policy Research in Education, University of Pennsylvania.

Creswell, J. W. (2013). *Qualitative research methods* (M. Bütün & S. B. Demir, Ed. & Trans.). Ankara: Siyasal Publishing.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory Into Practice, 39*(3), 124-130.

Çevik, N. (2008). *A qualitative study on the effect of teacher variables on participation and speaking levels of upper-intermediate students* (Unpublished master's thesis). Hacettepe University, Ankara.

Darling-Hammond, L., & Richardson, N. (2009). Research review/teacher learning: What matters. *Educational Leadership, 66*(5), 46-53.

Deboer, G. E. (2002). Student-centered teaching in a standards-based world: Finding a sensible balance. *Science & Education, 11*(4), 405-417.

Demir, S., Böyük, U., & Erol, M. (2012). Fen ve teknoloji öğretmenlerinin laboratuvar uygulamalarına yönelik hizmet içi eğitim programı: Mobilim eğitim. *Mustafa Kemal University Journal of Social Sciences Institute, 9*(19), 359-375.

Dikilitaş, K. (2013). *The impact of in-service teacher training: A case study of four novice teachers' beliefs and classroom practices* (Unpublished doctoral dissertation). Yeditepe University, İstanbul.

Dolfing, R., Prins, G. T., Bulte, A. M., Pilot, A., & Vermunt, J. D. (2021). Strategies to support teachers' professional development regarding sense-making in context-based science curricula. *Science Education, 105*(1), 127-165.

Ecevit, T., & Simsek, P. O. (2017). The evaluation of teachers' science concept teaching and their action to diagnose and eliminate misconceptions. *Elementary Education Online, 16*(1), 129-150.

Elliott, R. (1996). Discourse analysis: Exploring action, function and conflict in social texts. *Marketing Intelligence & Planning, 14*(6), 65-68.

Erten, S. (2002). Planlanmış davranış teorisi ile uygulamalı ders işleme öğretim metodu. *Hacettepe University Journal of the Faculty of Letters, 19*(2), 217-233.

Fidan, N. K., & Duman, T. (2014). Classroom teachers' possession level of characteristics required by the constructivist approach. *Education and Science, 39*(174), 143-159.

Franke, M. L., Carpenter, T. P., Levi, L., & Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Journal, 38*(3), 653-689.

Freeman, D. (2002). The hidden side of the work: Teacher knowledge and learning to teach. *Language Teaching, 35*, 1-13.

Gaines, R. E., Osman, D. J., Maddocks, D. L., Warner, J. R., Freeman, J. L., & Schallert, D. L. (2019). Teachers' emotional experiences in professional development: Where they come from and what they can mean. *Teaching and Teacher Education, 77*, 53-65.

Gess-Newsome, J. (2001). The professional development of science teachers for science education reform: A review of the research. In J. Rhoton & P. Bowers (Eds.), *Professional development: Planning and design* (pp. 91-100). Arlington, VA: NSTA Press.

Gess-Newsome, J., Taylor, J. A., Carlson, J., Gardner, A. L., Wilson, C. D., & Stuhlsatz, M. A. (2019). Teacher pedagogical content knowledge, practice, and student achievement. *International Journal of Science Education*, *41*(7), 944-963.

Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record, 103*, 942-1012.

Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching: Theory and Practice, 8*(3), 381-391.

Günel, M., Kıngır, S., & Geban, Ö. (2012). Analysis of argumentation and questioning patterns in argument-based inquiry classrooms. *Education and Science*, *37*(164), 316-330.

Güven, M., Alagöz-Hamzaj, Y., & Baldan, B. (2016). Milli eğitim şuralarında ve kalkınma planlarında öğretmenlerin hizmetiçi eğitimi. *Journal of Social Sciences, 3*(9),39-56.

Hanley, P., Wilson, H., Holligan, B., & Elliott, L. (2020). Thinking, doing, talking science: The effect on attainment and attitudes of a professional development programme to provide cognitively challenging primary science lessons. *International Journal of Science Education*, *42*(15), 2554-2573.

Hativa, N. (2000). Becoming a better teacher: A case of changing the pedagogical knowledge and beliefs of law professors. *Instructional Science, 28*, 491-523.

Hogan, K., & Pressley, M. (1997). *Scaffolding student learning: Instructional approaches and issues*. Cambridge, Mass: Brookline Books.

Johnson, C. C. (2006). Effective professional development and change in practice: Barriers science teachers encounter and implications for reform. *School Science and Mathematics, 106*(3), 150-161.

Kaçan, G. (2004). Sınıf öğretmenlerinin mesleki gelişime ilişkin isteklilik düzeyleri. *Eskişehir Osmangazi University Journal of Social Sciences*, *5*(1), 57-66.

Kaptan Acar, D., & Taşdemir, A. (2017). The needs of primary school teachers' pedagogical content knowledge for science learning and teaching. *International Journal of Eurasia Social Sciences*, *8*(30), 2281-2305.

Karaaslan, A. D. (2003). *Teachers perception of self-initiated professional development a case study on Başkent University English language teachers* (Unpublished master's thesis). Middle East Technical University, Ankara.

Kaya, G., Sardag, M., Cakmakci, G., Dogan, N., Irez, S., & Yalaki, Y. (2016). Discourse patterns and communication approaches used in teaching nature of science. *Education and Science*, *41*(185), 83-99.

Kennedy, A. (2005). Models of continuing professional development: A framework for analysis. *Journal of in-Service Education*, *31*(2), 235-250.

Kennedy, A. (2007). Continuing professional development (CPD) policy and the discourse of teacher professionalism in Scotland. *Research Papers in Education*, *22*(1), 95-111.

Kennedy, A. (2014). Understanding continuing professional development: The need for theory to impact on policy and practice. *Professional Development in Education*, *40*(5), 688-697.

Kıldan, A. O., & Temel, Z. F. (2008). Yapılandırmacı yaklaşıma dayalı oluşturulan hizmet içi eğitimin öğretmenlerin öğretmenlikle ilgili bazı görüşlerine etkisi. *Kastamonu Education Journal*, *16*(1), 25-36.

Kielborn, T. L., & Gilmer, P. J. (Eds.). (1999). *Meaningful science: Teachers doing inquiry-teaching science*. Tallahassee, FL: SERVE.

Kilic, M. S. (2018). *Determining behavioral purposes of teachers and teacher candidates to perform laboratory applications in science class through the theory of planned behavior* (Unpublished doctoral dissertation). Kastamonu University, Kastamonu.

King, F. (2011). The role of leadership in developing and sustaining teachers' professional learning. *Management in Education*, *25*(4), 149-155.

Koc, G. (2006). Teacher-learner roles and interaction systems in constructivist classrooms. *Education and Science*, *31*(142), 56-64.

Lamb, M. (1995). The Consequences of INSET. *ELT Journal, 49*(1), 72-29.

Lamie, J. M. (2004). Presenting a model of change. *Language Teaching Research, 8*(2), 115-142.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood, NJ: Ablex Lessons.

Lieberman, A., Saxl, E. R., & Miles, M. B. (2000). Teacher leadership: Ideology and practice. *The Jossey-Bass Reader on Educational Leadership*, *1*, 348-365.

Llewellyn, D. (2002). *Inquire within: Implementing inquiry- based science standarts*. Thousand Oaks, CA: Corwin Press.

Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1998). *Designing professional development for teachers of mathematics and science*. Thousand Oaks, CA: Corwin Press.

Martin, A. M., & Hand, B. (2009). Factors affecting the implementation of argument in the elementary science classroom. A longitudinal case study. *Research in Science Education*, *39*(1), 17-38.

Martin, D. J. (2012). *Elementary science methods: A constructivist approach*. Belmont, CA: Wadsworth Cengage Learning.

Martin, E., & Lueckenhausen, G. (2005). How university teaching changes teachers: Affective as well as cognitive challenges. *Higher Education, 49*, 389-412.

Maslow, A. H. (1958). A dynamic theory of human motivation. In C. L. Stacey & M. DeMartino (Eds.), *Understanding human motivation* (pp. 26-47). Howard Allen Publishers. doi:10.1037/11305-004

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* Thousand Oaks, CA: Sage.

Ministry of National Education. (2010). *Milli Eğitim Bakanlığında Hizmet içi Eğitimin Yeniden Yapılandırılması Panel ve Çalıştayı*. Ankara: Ministry of National Education Department of In-Service Training.

Ministry of National Education. (2013). *İlköğretim Kurumları Fen bilimleri dersi öğretim programı*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classrooms.* Buckingham: Open University Press.

Mulholland, J., & Wallace, J. (2005). Growing the tree of teacher knowledge: Ten years of learning to teach elementary science, *Teachers and Teaching: Theory and Practice, 42*(7), 767-790.

Murphy, J. (Ed.). (2005). *Connecting teacher leadership and school improvement*. Thousand Oaks, CA: Corwin Press.

Nguyen, B. H., Haworth, P., & Hansen, S. (2019). Challenging ESP teacher beliefs about active learning in a Vietnamese university. *Teacher Development, 23*(3), 345-365.

Nuckles, C. R. (2000). Student-centered teaching: Making it work. *Adult Learning, 11*(4), 5-6.

Opfer, V. D., & Pedder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research*, *81*(3), 376-407.

Ozenc, M., & Dogan, C. (2007). Determining the competency levels of primary teachers in the constructivist approach. *Abant Izzet Baysal University Education Faculty Journal, 12*(1), 67-83.

Ozer, B. (2008). Öğretmenlerin mesleki gelişimi. In A. Hakan (Ed.), *Öğretmenlik meslek bilgisi alanındaki gelişmeler* (pp. 195-216). Eskisehir: Anadolu University Faculty of Open University.

Patton, M. Q. (2005). *Qualitative research.* New York: John Wiley & Sons.

Pierce, W. (2001). Inquiry made easy. *Science and Children, 38*(8), 39-41.

Pillar, G. A., Prudente, M. S., & Aguja, S. E. (2015). Using interactive applications in enhancing students' knowledge and technical skills and process skills in grade 4 science. *Advanced Science Letters, 21*(7), 2266-2270.

Pusmaz, A. (2008). *Matematik öğretmenlerinin problem çözme sürecinin belirlenmesi ve bu sürecin geliştirilmesinde web tabanlı mesleki gelişim çalışmalarının değerlendirilmesi* (Unpublished doctoral dissertation). Marmara University, İstanbul.

Sachs, J. (2001). Teacher professional identity: Competing discourses, competing outcomes. *Journal of Education Policy*, *16*(2), 149-161.

Sachs, J. (2016). Teacher professionalism: Why are we still talking about it?. *Teachers and Teaching, 22*(4), 413-425.

Sadler, I. (2013). The role of self-confidence in learning to teach in higher education. *Innovations in Education and Teaching International*, *50*(2), 157-166.

Sanchez, S. H. (2012). The impact of self-perceived subject matter knowledge on pedagogical decisions in EFL grammar teaching practices. *Language Awareness, 23*(3), 220-233.

Santoro, N., & Kennedy, A. (2016). How is cultural diversity positioned in teacher professional standards? An international analysis. *Asia-Pacific Journal of Teacher Education*, *44*(3), 208-223.

Schwab, J. J. (1962). The teaching of science as enquiry. In J. J. Schwab & P. F. Brandwein (Eds.), *The teaching of science* (pp. 1-103). Cambridge, MA: Harvard University Press.

Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education*, *90*(4), 605-631.

Seedhouse, P. (2004). *The interactional architecture of the language classroom: A Conversation analysis perspective.* Oxford: Blackwell.

Smith, R. G. (2007). Developing professional identities and knowledge: Becoming primary teachers. *Teachers and Teaching: Theory and Practice*, *13*(4), 377-397.

Smyth, J., Dow, A., Hattam, R., Reid, A., & Shacklock, G. (2000). *Teachers' work in a globalizing economy.* London: Falmer Press.

Soysal, Y., & Tanik, H. (2017). Investigating academicians' attributions for educational barriers within the context of pedagogical-epistemological belief systems. *Journal of Higher Education and Science, 7*(2), 333-352.

Soysal, Y., Tanik, H., & Tunali, S. (2019). An exploration of causal attributions of teacher educators: A single case study. *Istanbul Aydın University Faculty of Education Journal, 2*(2), 107-131.

Stone, A. (1998). The metaphor of scaffolding: Its utility for the field of learning disabilities. *Journal of Learning Disabilities, 3*(4), 344-364.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980.

Şişman, M. (2009). Öğretmen yeterlilikleri: Modern bir söylem ve retorik. *Inonu University Journal of the Faculty of Education, 10*(3), 63-82.

Wang, D. (2011). The dilemma of time: Student-centered teaching in the rural classroom in China. *Teaching and Teacher Education, 27*(1), 157-164.

Wells, G. (1999). *Dialogic inquiry: Toward a sociocultural practice and theory of education.* Cambridge: Cambridge University Press.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice?. *Science Education*, *87*(1), 112-143. doi:10.1002/sce.10044

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100.

Yin, R. K. (2009). *Case study research: Design and methods.* Thousand Oaks, CA: Sage.

Yoon, H. G., Joung, Y. J., & Kim, M. (2011). The challenges of science inquiry teaching for pre-service teachers in elementary classrooms: Difficulties on and under the scene. *Research in Science Education, 42*(3), 589-608.

Yoon, H.-G., & Kim, M. (2010). Collaborative reflection through dilemma cases of science practical work during practicum. *International Journal of Science Education, 32*(3), 283-301.

Yörükoğlu, A. (2000). *Gençlik çağı.* İstanbul: Ozgur Publications.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, *25*(1), 82-91.