Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 16, Sayı 2, Aralık 2022, sayfa 381-405. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 16, Issue 2, December 2022, pp. 381-405. ISSN: 1307-6086

Research Article

Prospective Science Teachers' Arguments Regarding a Discrepant Event and Their Thoughts on Using Them in Science Education

Oktay KIZKAPAN

[1] Nevşehir Hacı Bektaş Veli University Department of Educational Sciences, Nevşehir/Turkiye, okizkapan@nevsehir.edu.tr, http://orcid.org/0000-0001-6781-9879

Received : 3.4.2022 Accepted : 5.11.2022
Doi: 10.17522/balikesirnef.1097727

Abstract – The aim of this study is to determine the prospective science teachers' (PSTs) arguments about a discrepant event and their views on the use of such discrepant events in science education. In the study, an instrumental case study, one of the qualitative research designs, was adopted. The study group of the research consisted of 73 prospective teachers studying at science education department of a stated university located in Central Anatolia Region of Turkey. The data of the research was collected by using written documents. The collected data in the study were analyzed using descriptive analysis. Analysis showed that the prospective science teachers' individual arguments about the discrepant event were weak and insufficient to explain the discrepancy. When prospective science teachers are provided with additional information and encouraged to cooperate effectively and allowed to work as a group, the quality and explanatory power of the arguments increased. However, it was observed that prospective teachers were not able to produce high-level arguments when they worked neither individually nor as a group.

Key words: discrepant events, science education, argumentation, chemistry education.

Introduction

Advent of Covid-19 pandemic changed educational environments dramatically. As a result of this change, distance education has become the reality of the lives of students and teachers. This reality has brought some problems together. One of these problems is lack of student interaction (Taşçı, 2021). Therefore, distance education environments should be student-centered. As a matter of fact, research show that teacher-centered teaching methods such as direct instruction and question-answer are mostly used in distance education

(Bakioğlu & Çevik, 2020). However, this situation must be changed. Therefore, there is a need for contents and activities that can be used in distance education environments, in accordance with the constructivist approach, and which will improve students' understanding by making them undergo a conceptual change. This need can be met if in-service and prospective teachers can carry out activities that will bring about conceptual change in students in educational environments.

According to Piaget, one of the advocates of cognitive theory, the cognitive equilibrium state of the individual deteriorates as a result of a new phenomenon. Then, with the explanation about the phenomenon that caused the deterioration, a more developed rebalance can be established (Senemoğlu, 2010). Individuals continue their learning in a cycle of balance, imbalance, and rebalance as a result of social and environmental interactions. Therefore, the main task of educational environments is to confront students with situations that will create a cognitive conflict.

According to the conceptual change theory which is a frequently discussed topic in science education (Harteis et al., 2020), the students need to stay in a cognitively contradictory condition for the conceptual change to take place. Science educators aim to teach the concepts that are accepted as scientifically correct and to change the conceptual structures that exist in students (Vaughn et al., 2020). Different models have been proposed for conceptual change. For example, while Sinatra et al. (2014) suggested adding emotional variables such as engagement, motivation and self-threat to conceptual change models, Nadelson et al. (2018) suggested a more contemporary dynamic model. According to conceptual change theory suggested by Posner et al. (1982), students should be exposed to phenomenon that contradict their ideas and should be aware of the inadequacies of their own explanations. Therefore, they should be exposed to cognitive conflicts (Appleton, 1996). In this way, students can search for alternative explanations to solve the contradictory situation caused by a natural effort to get rid of the contradictory situation they are in. Thus, they will learn as a result of cognitive conflicts and resolving these conflicts (Limón, 2001), which will motivate them to learn.

In the literature, there are different teaching methods, techniques and tools developed to confront students with situations that create a cognitive contradiction. One of these tools is discrepant events (González-Espada et al., 2010). Discrepant events defined as situations that are inconsistent with intuitive expectations (Mason et al., 2004) are effective tools that can be used to increase students' interest in science and their motivation to learn scientific principles and concepts more conceptually (Wright & Govindarajan, 1992). Discrepant events are used in physics, chemistry, biology, social sciences, and teacher training (O'Brien et al., 1994). Besides in these areas, "discrepant events are very powerful ways to stimulate interest, motivate students to challenge their covert science misconceptions, and promote higher-order thinking skills" (González-Espada et al., 2010: 508).

According to Suprapto (2020), there are five types of misconceptions as preconceived notions, non-scientific beliefs, conceptual misunderstandings, misconceptions of local languages and factual misconceptions. Besides; students, teachers, teaching materials or literature, context and teaching methods are the main reasons of these misconceptions. Therefore, to overcome misconceptions, the types of misconceptions and their resources should be considered and well-known by educators. As the types and sources of misconceptions are known, there are also solutions for how to eliminate the misconceptions. At this point, using discrepant events can be helpful because when students face a discrepancy, they show a strong desire to resolve it. By this desire, students start to search for possible explanations (Kavogli, 1992). When they find a satisfying explanation, they make a conceptual transformation in their minds. In this way, students do not have misconceptions while learning the new subjects, and they can also overcome their existing misconceptions. Also, when students realize a discrepancy in a scientific phenomenon, they start to question and re-think about the phenomenon. Accordingly, they need additional information and start to search to revise their explanations. Through these struggles, they stay focused on the concept they are trying to understand. As a result, students develop a more conceptual understanding of the content knowledge they aim to learn (Blikstein et al., 2016; Hewson & Hewson, 1984). Hence, it can be inferred that discrepant events are effective tools that can be used to develop students' content knowledge, avoid and eliminate misconceptions by creating conceptual contradictions.

Although it is known that exposing students to situations that create cognitive conflict is effective in science education, teachers face various issues in taking such activities to the classroom. Being worried not to be on time on the schedule, difficulty to control the classroom management during group activities, lack of experimental materials, and the tendency of distinguishing lessons as theoretical and experimental are some of these issues (de Oliveira & Fischer, 2017). Despite the teachers' concerns, discrepant events can be integrated into the argumentation processes effectively using the predict-observe-explain (POE) technique (e.g. Shemwell & Furtak, 2010). In using the POE technique, students are required to predict the outcomes of an experiment or demonstration, justify their prediction, observe the demonstration, and then clarify discrepancies between their prediction and observation. Studies have shown that POE is effective in developing students' skills (Sarah et al., 2021), increases students' problem-solving skills and self-efficacy (Fitriani et al., 2020) and students' POE attitudes positively predict students' self-confidence and critical attitudes (Hong et al., 2021). It is also known that the POE technique is widely used as an assessment tool for science education at different levels (White & Gunstone, 1992, cited in Karamustafaoğlu & Mamlok-Naman, 2015). Considering these aspects, the POE can be used to determine PSTs' arguments in discrepant event activities.

In online and traditional science learning environment, several approaches have been used to increase students' argumentation abilities. As one of these approaches, discrepant events can be used as effective tools in either online or face to face argumentative instructions, since they promote and support argumentation in science lessons. Discrepant events are productive contexts in which students are required to engage in argumentation to make sense of a given situation. Sampson and Clark (2009) state that when students craft convincing and persuasive arguments with the available data regarding a discrepant event, they learn about not only the content knowledge related to the discrepant event, but also about the argumentation. Therefore, discrepant events are used as a tool to help students to learn how to engage in scientific argumentation (Sampson & Clark, 2009; Sampson et al., 2011). Also, discrepant events and argumentation have a mutual effect on conceptual change. Both argumentation and discrepant events facilitate conceptual change in scientific knowledge. In other words, if teachers have adequate pedagogical knowledge about discrepant events and argumentation to utilize them in their science lessons, they can successfully bring about significant change in their students' perception towards science content knowledge (Anderson & Smith, 1983).

Discrepant events can be performed in the form of demonstration experiments as individual or small group activities. In this way, students' attention can be drawn, and they can be canalized to scientific research without requiring a long time (Mancuso, 2010). Therefore, PSTs need to be familiar with preparing and implementing such activities so that they can easily carry these activities into their future science classrooms. In this regard, in science teacher education program of Turkey, PSTs learn about argumentation in some courses such as science teaching and learning approaches, science teaching I and II, scientific reasoning skills and nature of science and its teaching (Council of Higher Education [CoHE], 2018). Indeed, they learn about POE technique in science teaching II and scientific reasoning skills courses. Therefore, after completing these courses, PSTs gain basic pedagogical knowledge and skills, and become familiar to argumentation. However, being familiar to argumentation is not enough for PSTs to carry out argumentative-based instructions by using discrepant events in their future science classes. To accomplish this, PSTs should also have a certain level of content knowledge and hold positive views about the possible contribution of these events for science lessons. Thus, PSTs' arguments about a discrepant event can provide information about their ability to produce qualified arguments using their content knowledge. Also, by examining their views about the use of discrepant events, their willingness to use these events in science lessons can be predicted. Based on these reasons, this study aims to determine prospective science teachers’ arguments about a discrepant event and their views on the use of these events in science education. The research questions determined for this purpose are as follows;

1) What arguments do the prospective science teachers create while predicting and explaining the results of a discrepant event?

2) What opinions do the prospective science teachers express regarding the use of discrepant events in science education?

Method

Research Design

An instrumental case study, one of the qualitative research method designs, was employed in this research. In instrumental case studies, the researcher focuses on an issue, problem or concern, and then selects a case to examine this issue (Creswell & Poth, 2018). Instrumental case study enables researchers to investigate a situation and test established perspectives on it. Moreover, similarities and differences within the boundaries that define a situation can be identified. Instrumental case study design is also used when a general understanding of a research question is needed and when it is desired to gain insight into the question by examining a particular case. In other words, researchers use a specific case to gain insight into an issue or theory (Stake, 1995). In this study, the researcher used a sample discrepant event to reveal if PSTs can craft strong arguments in the explanation of the sample event and to ascertain their thoughts about the use of these types of events in science education. In this regard, an instrumental case study design was utilized to determine whether the PSTs could explain a discrepant event using their content knowledge, the arguments PSTs develop in their attempts to explain the discrepant event, and their views on the use of discrepant events in science education.

Participants

The study group of the research is consisted of PSTs studying at third and fourth grades of science education department of a state university in Turkey. The study group was determined by using convenience sampling. In this context, PSTs in the department where the researcher works are included in the study. The first application of the activity was conducted with 33 PSTs studying in the third grade. However, the third grade prospective teachers had difficulties in explaining the discrepant event and in producing strong arguments when they studied individually. Thereupon, the research was repeated with fourth grade students. In this second application, students were asked to work in groups. The second application was carried out with 40 PSTs studying in the fourth grade in the same department. Thus, 73 PSTs participated in the study in total. The PSTs who participated in both applications of the activity have completed all physics and chemistry courses in the undergraduate programs. PSTs in the first application were coded as P1, P2, P3…, P33. In the second application, PSTs formed 10 groups and worked in groups. These groups were coded as G1, G2, G3,… G10. Although working in groups do not make a significance effect on the performance of students in tasks that require memorization and rote learning (Phelps & Damon, 1989), students working in groups perform significantly better than the ones working individually in complex and conceptual tasks (Barron, 2000) such as argumentation activities. Therefore, PSTs were asked to work in groups in the second application.

Data collection

Documents are one of the data sources in qualitative research. Examination of documents includes the use of written documents containing information about the situations desired to be studied (Yıldırım & Şimşek, 2011). In this research, written documents by PSTs were used as a data collection tool to determine the arguments of the prospective science teachers regarding a discrepant event. In this context, as a document, a paper was distributed by the researcher on which the prospective science teachers can write their predictions, observations and explanations about the discrepant event. There were four questions on the document as "What is your prediction?", "What did you observe?", "What is your explanation?" and "What do you think about use of this discrepant event in a science class? Why?" After the discrepant event was introduced, the prospective teachers wrote their predictions under the relevant title. Then, the activity was conducted and the groups of PSTs wrote their observations, explanations and their thought about the use of discrepant events under each related question with their justification. During the activity, the researcher followed and directed the individual and group discussions and enabled all prospective teachers to participate in the discussion. Then, the papers were collected and analyzed by the researcher. All the collected data in the research was in Turkish since the language of the education was Turkish and PSTs did not speak in English. Therefore, all the written material was translated into English by the researcher before the analysis.

Research Procedures

The discrepant event used in the research is adopted from a video called “discrepant balloons” (FlinnScientific, 2012). The activity in the video shared on YouTube was carried to the classroom environment by the researcher, and the same experimental setup was created in the classroom. In the discrepant balloon activity, two identical balloons were inflated to be approximately one liter and three liters respectively, and the balloons were connected to each other through a tube that allow air to pass between the two balloons. The visual of the discrepant balloon activity is given in Figure 1.

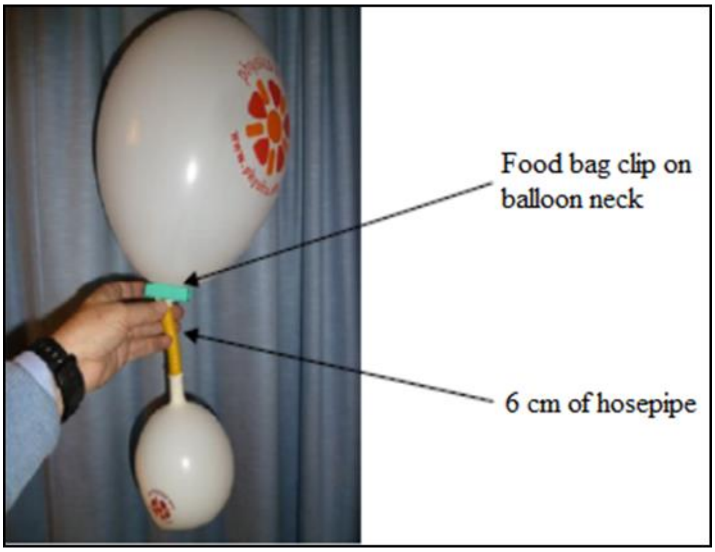

Figure 1. A picture of discrepant balloon activity (Figure is from Ješková et al., 2012)

Two balloons were connected as in Figure 1 and the airflow between the balloons was prevented. Prospective teachers were asked if the air passes from one balloon to the other when airflow is allowed, and if so, in which direction the air will flow. After PSTs wrote their predictions, airflow was allowed between the balloons. As a result of the event, it was observed that all the air in the small balloon passed into the larger one.

In the activity carried out in this research, it is expected that when airflow between the balloons is allowed, air will flow from the large balloon to the small balloon and the volumes will be equalized. However, the result of the activity was the opposite of this expectation. The reason for this situation can be explained by the amount of increase in surface areas of the balloons. When the volume of a balloon increases from one litter to two litters, its surface area increases 285 cm^2. However, when the volume of a balloon increases from 3 litters to 4 litters, the surface area of the balloon increases only 213 cm^2. The discrepancy in the behaviors of the balloons can also be experienced in daily life when a balloon is inflated. The most difficult blow into a balloon is the first one because the increase in the surface area of the balloon in the first blow is the highest, as seen in Table 1. An equal amount of air in each subsequent blow will result in a smaller increase in surface area.

Discrepant balloons activity contains a discrepancy. Therefore, it can be used to trigger argumentation process in science lessons. In this scope, the discrepant balloon activity was carried out and PSTs were asked to explain the discrepancy in this activity. The activity was carried out in two stages. In the first stage, PSTs were introduced to the discrepant event, and they were asked to express their predictions about the behaviors of balloons. Then, discrepant balloons activity was demonstrated. After that, PSTs were asked to write their observations and explanations about the results of the activity. The predictions and explanations of PST were analyzed by the researcher. As a result of the analysis, it was seen that there were important deficiencies and inaccuracies in the explanations of the PSTs, and it was decided to re-organize the activity with a different group of PSTs by giving some supportive information.

Before the second demonstration, the researcher set a session with PSTs to introduce the discrepant balloon activity, Toulmin Argumentation Pattern (2003), and POE technique. In this session, the researcher introduced Toulmin model, explained its components and gave examples of strong and weak arguments from science education topics on the smart board in a science laboratory. Also, each step of POE technique was introduced and reminded to PSTs in this session. PSTs were asked to craft convincing, persuasive and strong arguments composing of justification, qualifier and multiple rebuttals as in the examples that researcher showed. In other words, they were asked to justify their claims and create strong arguments by using their content knowledge. Before the discrepant balloon activity was conducted by the researcher, PSTs were asked to create their arguments regarding their predictions about the activity.

While the PSTs were making predictions about the discrepant event in the second application, firstly, they held small group discussions within their groups. In these small group discussions, they were asked to create an argument about what is going to happen when the airflow is allowed between balloons and why. They were asked to defend their arguments to group members. After consensus was reached in small groups, all groups explained their arguments regarding their predictions to the researcher and other groups. After listening to the arguments of all groups, the researcher performed the demonstration. Besides the demonstration, some information about the volumes, radii, and surface areas of the balloons (Table 1) (FlinnScientific, 2012) and a graph showing the radius-pressure change of a balloon (Figure 2) was shared with PSTs to support them with some extra information. The information provided to PSTs about the activity was adapted from the research by Ješková et al. (2012). PSTs were asked to consider both their observations and the given information in their explanations about the discrepant event. Then, PSTs were allowed to re-evaluate the arguments they formed in the prediction phase. Thereby, they started a new argumentation process within their groups based on their observation and the information given to them. At this step, they either developed their previous argument or formed a new one.

Small group discussions to explain the observed discrepancy continued until a consensus was reached in each group. Then, the researcher listened to the groups' arguments one by one and started whole class discussions between the groups. After enough time was given to the discussions between all groups, the groups were asked to express in written form whether their ideas have changed or not. Lastly, the PSTs were asked about the possible contributions of using the discrepant events in science education, and they were asked to write their opinions. The activity ended after PSTs wrote their opinions.

Table 1. Information about balloons

Volume (cm^3)	Radii (cm)	Surface Area (cm^2)
0	0	0
1000	6.20	483
2000	7.82	768
3000	8.95	1006
4000	9.85	1219

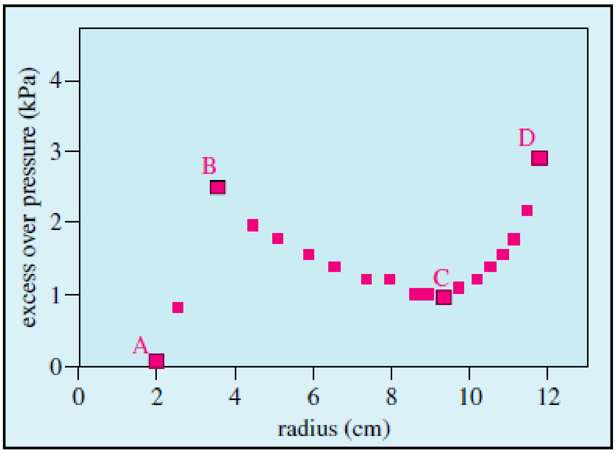

Figure 2. Experimental result of pressure versus radius for a balloon (Ješková et al., 2012)

Data Analysis

Descriptive analysis was used in the analysis of the data of this research. Descriptive analysis includes summarizing and interpreting qualitative data collected by different methods based on predetermined themes. In descriptive analysis, direct quotations can be frequently used in order to present the feelings and thoughts of the people with whom the researcher directly interacted. The purpose of the descriptive analysis method is to transfer the obtained data to the reader in a collective and interpreted manner. Descriptive analysis takes place in four stages. These stages are creating the framework required for descriptive analysis, processing the data, identifying the findings and interpreting them (Altunışık et al. 2010; Yıldırım & Şimşek, 2011). In the first stage, the limits of data analysis were drawn by the researcher based on the research problems and the collected data. In this study, data about the PSTs' arguments regarding the discrepant event and opinions about the use of discrepant events in science education were obtained. In the second stage, the researcher put the data into a framework that was previously created. The data for the first research question was listed under the themes determined in accordance with the phases of POE technique. Sub-themes were created based on the components of an argument and were separately given under the relevant themes. The data regarding the second research question were coded as labelling the participants' views. In the third stage, the findings put into order by the researcher are explained. Direct quotations can be given where needed in this stage. In this study, findings were presented with direct quotations of PSTs. In the fourth stage, researchers explain the findings and interpret the meaning by establishing a link between them. In this study, logical inferences in the scope of the fourth stage were made in the conclusion and discussion section.

Validity and reliability

In the research expert approval was obtained before using the POE form to ensure the credibility of the research. In this regard , opinions of one expert at educational sciences were taken regarding the prepared interview form. Also, two experts at science education examined the discrepant event activity and approved the discrepancy and explanation suggested by the researcher. Also, research design is approved by these experts. The research model, study group, data collection tools and procedures, data analysis and were organized are described in detail in method section to ensure transferability. In addition, the participants of the study were prospective science teachers who can contribute to the purpose of the study. However, relatively small number of participants can be shown as a limitation for transferability. In terms of dependability (internal reliability), findings of the research were presented without comment, and data loss was prevented since the data is collected through written documents. In addition, the codes created by the researcher is examined and approved by an external researcher who is experienced in qualitative research for confirmability (external reliability). Finally, the results are appropriately discussed in accordance with the present literature. Therefore, the confirmability of the study was aimed to be increased.

Findings and Discussions

Findings Regarding PSTs' Arguments in First Application

The discrepant balloons activity used in the research was first demonstrated to 33 PSTs. In this context, firstly, findings related to the predictions, observations and explanations of prospective teachers about discrepant event are given in Table 2.

Table 2. Codes and themes from the first application

Theme	Codes	Participants
Prediction	Both balloons deflate	P2, P31
	Smaller balloon deflate completely, bigger balloon deflate partially	P1, P3
	The bigger balloon deflates some, the smaller balloon inflates some and they come to equal volume.	P4, P5, P6, P9, P15, P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, P29, P30, P32, P33
	The smaller balloon deflates completely, the bigger balloon inflates.	P7, P8, P11, P12, P13
	Volumes remain unchanged	P10, P14
Observation	The smaller balloon deflated completely, the bigger balloon inflated.	All of the participants
Explanation	Density difference	P1, P2, P3, P7, P10, P28, P29
	Low gas pressure in the small balloon	P1, P4, P25, P31

	Low gas pressure in the bigger balloon	P8, P11, P13, P15, P16, P17, P18, P19, P20, P21, P22, P24, P26, P27, P30
	Small amount of gas in the small balloon	P5, P6, P18
	Volume difference	P9, P10, P12,
	Expansion	P14

* P23, P32 and P33 could not make any explanation regarding the cause of the event. In addition, some participants' (P1, P10 and P18) explanations could be collected under two different codes.

In the study, the predictions of PSTs regarding discrepant balloons activity were determined. Two participants (P2 and P31) stated that both balloons would be completely deflated. Among them, P31 expressed her thoughts as "*If the clip between two balloons is opened, both balloons will be deflated*". Among PSTs who think that the small balloon will be completely deflated and the large balloon will partially deflate, P1 stated that "*while the small balloon goes out, larger balloon also goes out partially. So a big part of larger balloon goes out.*" On the other hand, most of the PSTs predicted that the big balloon would deflate a little and the small balloon would swell a little and eventually they come to equal volumes. P6's prediction is as fallows "*Air flow from bigger balloon to small one. It continues until the volumes of two balloons are equalized*." Some of the PSTs made the correct prediction about the activity. P8 who predicted that the small balloon would completely deflate and the large balloon would swell stated her prediction as;

> "*The air passes from the small balloon to the big balloon. Since the volume of the small balloon is low, its pressure is high. Due to the high pressure, the air passes from the small balloon to the big one. So the big balloon will inflate more.*"

The PSTs coded as P10 and P14, stated that when air passage between the balloons is allowed, there will be no change in the size of the balloons. P14 stated his opinion as, "*I think balloons remain the same. There will be no change. In order for diffusion to occur, the volume of the small balloon must increase.*"

Discrepant balloons activity was held after PSTs expressed their predictions in writing. All PSTs stated in their observations that the small balloon completely deflated and the large balloon swelled more. After the prospective science teachers explained their observations, they were asked to explain the reason of the situation.

When the answers of the PSTs are examined, it is seen that they emphasized certain concepts such as density, gas pressure, gas amount and expansion in order to explain the behaviors of the balloons. According to P1 who thinks that the air in the small balloon passed to larger one due to the difference in density. To reveal her ideas, she stated that "*the small balloon went out, the big balloon swelled because the gas density in the small balloon was less than the gas density in the large one*". P31 emphasized to the low gas pressure in the small balloon and stated that;

> "*Since the gas pressure in the small balloon is less, the large balloon with more air does not go out. The gas in the small balloon passes into the big one. It goes out as the gas pressure is low in the small balloon*."

Most of the PSTs explained the discrepant event with the large gas pressure in the big balloon. For example, P13 expressed his opinion on this issue as follows;

> "*The small balloon completely deflated because its volume was small. (Therefore) the pressure was high… The volume of the big balloon was large. So, the pressure was low. Air flows from high pressure to the low."*

Three PSTs explained the discrepancy in the activity with the amount of gas in the balloons. P6 explained his opinion as "*I think that the small balloon deflated because there is less amount of gas in it*". Explaining the discrepant event with the different volumes of the balloons, P10 thoughts are as fallows; "*since the volume of the small balloon is smaller than the large one, there was a gas transition from the small balloon to the large. I mean because of the difference in volume*." Explaining the discrepant event through the concept of expansion, P14 explained her thought as "since the large balloon has expanded more, the pressure of the small balloon has effected easily on the large balloon".

In the first application, while the PSTs' arguments about their predictions consisted of only the claim. In the second application, with the guidance of the researcher, the PSTs were able to create more developed arguments consisting of the claim and warrants. Although PSTs were able to create arguments consisting of the claim and warrants, argument components such as rebuttal and backing were not found in any argument. From this aspect, it can be said that the arguments created in the first application are quite weak. This means that PSTs' content knowledge regarding the pressure, diffusion, and density concepts is superficial or they cannot use their content knowledge to explain a phenomenon. In the literature, there are results reporting that PSTs have difficulties in producing high-level arguments containing rebuttal and backing (Erduran et al., 2004; Hiğde & Aktamış, 2017). Regarding their content knowledge, for example, it is seen that PSTs have difficulty in explaining the relationship between pressure, volume and density. By associating pressure only with volume and ignoring other variables such as temperature and the amount of air, they reach the proposition that pressure increases as the volume decreases. Similarly, PSTs in G8 associated pressure only with the amount of air in the balloons and neglected the volume. In one group, students' justification was not even scientific. The PSTs in this group stated that there is a balance in nature and therefore, balloons must behave in line with the balance of the nature, which shows that PSTs in G9 justified their claim with a non-scientific "argument". The justification of this group was teleological rather than scientific. This shows that, PSTs have not developed conceptual understanding in pressure concept. The most important reason for this situation is that PSTs learn about physics and chemistry concepts with an approach far from daily life practices. More precisely, they tend to learn these concepts by memorizing. Therefore, the insufficiency in content knowledge is an obstacle for PSTs to produce strong scientific arguments. Supporting these results, it is stated in the literature that the pedagogical competencies of teachers highly depend on their content knowledge (Canbazoğlu et al., 2010; Magnusson et al., 1999). Besides, there are also supporting results in the literature that teachers tend to ask more superficial questions while teaching the subjects on which their content knowledge is insufficient (Carlsen, 1999).

Findings Regarding PSTs' Arguments in Second Application

The discrepant balloons activity was demonstrated to a group of PSTs. In this context, findings related to the predictions, observations, and explanations of prospective teachers about the discrepant event are given in Table 3.

Table 3. Codes and themes from the data

Theme	Sub-theme	Code	Groups
Prediction	Claim	The bigger balloon deflates some, the smaller balloon inflates some and they come to equal volume.	G1, G5, G6, G7, G8, G9, G10
		The smaller balloon deflates completely, the bigger balloon inflates.	G2, G3, G4
	Warrant	Diffusion	G1, G5
		The internal pressure of the small balloon is higher.	G4,
		The internal pressure of the large balloon is higher.	G6, G7
		There is more air in the big balloon.	G8
		There is a balance in nature.	G9
		Gases pass from high density to low.	G10

Observation		The smaller balloon deflated completely, the bigger balloon inflated.	All of the groups
Explanation	Warrant	The pressure decreases as the surface area and radius of the balloon increase	G1
		The pressure increases as the surface area decreases	G2, G4
		External pressure decreases as the membrane gets thinner	G2
		The balloons will swell harder when its membrane is thick	G3
		As the balloon swells, its elasticity changes	G6
		The membrane of the small balloon exerts less force on the air in it	G7
		The membrane of the small balloon is thicker	G8
		The big balloon flexes more easily than the small one	G9
		The pressure decreases as the radius increases	G1, G10

In the research, PSTs groups were asked to write their predictions with their justifications. When the predictions of PSTs groups were examined, two codes regarding their claims were formed. Some groups of the PSTs stated that there would be an air transition from the big balloon to the small one until the volumes of the balloons were equalized. For example, PSTs in group six (G6) expressed their views on this issue as "*Air flows from the larger balloon to the small balloon, and air passes until their volumes are equalized.*"

Similarly, PSTs in G1 stated that "*there will be air flow from large to the small balloon. When they come to the same size, air flow stops.*" On the other hand, some groups of the PSTs expressed that when the clip between the balloons was opened, the small balloon would completely deflate and the large balloon would inflate a little more. For example, the PSTs in the fourth group (G4) revealed their thoughts as "*air passes from small balloon to large balloon.*" Similarly, PSTs in G3 stated that "air pass from small balloon to the large one. Small balloon deflates completely."

In the research, PSTs in groups were asked to justify their predictions. It is noteworthy that PSTs emphasized diffusion, pressure, density, and balance concepts in their justifications. For example, PSTs in the G5 who thought that air would pass from the big balloon to the small balloon due to the diffusion justified their thoughts as "*they will be equalized in volume because the air passes from high density to low due to the diffusion rule*." PSTs in G4, G6, and G7 used the pressure concept to justify their claims. The PSTs in the G4 thought that the internal gas pressure in the small balloon was higher. They expressed their thoughts as "*The volume of the small balloon is low. Therefore, the internal pressure is high. Large balloon has a high volume and internal pressure is low*."

The PSTs in G6 thought that the internal pressure of the big balloon was higher, and they explained their thoughts as "*because the air pressure is too high in the larger balloon, air passes into the small balloon. The air passage continues until their pressures are equalized*." The PSTs in G8 justified their claim by referring to the amount of the air in the balloons. They uttered that "*air passes from larger balloon to the small one because the amount of air in the larger balloon is much more than that of the small balloon*." The PSTs in the G9 put forward a metaphysical justification for their claims. Their justification was *"… the air transition continues until the balloons reach equilibrium because the air is a fluid and there is a balance in nature*."

After their argument in the prediction phase, all groups observed that all the air in the small balloon passed to the larger balloon. Therefore, all groups reported this observation commonly. In this context, there was no difference in terms of the observations of the groups.

In the third stage of POE, PSTs in groups were asked to explain the reasons for the results of the discrepant event. In other words, they were asked to write why all the air in the small balloon passed into the large balloon. When the answers of PSTs groups were examined, it was seen in their explanation that, they emphasized the surface area, radii, and membrane factors. For example, PSTs in G1, who emphasized the surface area and radius, explained their thoughts as "*the large balloon has more surface area and radius. This means the pressure of the big balloon is smaller and the pressure of the small balloon is higher. Air passes from high pressure to low pressure*."

PSTs in G2 highlighted the surface area and noted that "*since the small balloon has a small surface area, it has a higher pressure. Therefore, air passed from small balloon to the large one*". PSTs in G2 also made a contradictory justification. They stated that "*external air pressure is equal for both balloons…as the membrane of the balloon gets thinner, external air pressure decreases*." On the other hand, it was seen that PSTs in many groups (G2, G3, G6, G7, G8 and G9) emphasized the membrane of the balloon to explain the discrepant event. For example, the PSTs in G3 explained their opinions as "*when we try to blow up a balloon, it is difficult to inflate it because its membrane is thick*." Also, PSTs in G8 asserted that "*since the membrane of the small balloon is thicker, it does not tend to swell*." Similarly, PSTs in G6 explained the situation as follows;

> "*….the reason for this may be that the flexibility of the balloon changes over time when we blow into the balloon. … Because the small balloon is less flexible and the large balloon is more flexible, the air in the small balloon can easily pass into the large balloon*."

In the second application, it was seen that the PSTs' arguments regarding the results of the activity were relatively more qualified and the power of explanation was higher. Also, arguments regarding the results of the activity were relatively more qualified and the power of explanation was higher compared to the arguments in first application. The main reasons for the increase of the argument quality may be additional information provided and working as a group. Thanks to peer instruction and peer inquiry in group work, PSTs were able to see the deficiencies or errors in their own ideas, and they were able to look critically. In this way, they were able to generate stronger arguments. In this regard, groups referred to the information such as surface area and radii given them. Supporting, previous studies reported that providing supportive information to students enables students to produce more qualified arguments (Akbayrak & Namdar, 2019; Schworm & Renkl, 2007). In addition, PSTs explained the results of the activity by making logical inferences from the available data. Therefore, it can be said that especially small group discussions helped PSTs to think analytically. In the literature, there are studies supporting the results in the research that peer instruction and peer inquiry improve conceptual learning (Kızkapan & Bektaş, 2021; Mazur, 1997). Based on these results, it can be said that activities that will enable individuals to produce qualified arguments with very cheap materials and correct pedagogical methods can be held in science classes.

Findings Regarding the Use of the Discrepant Event in Science Classrooms

Within the scope of the second sub-problem of the research, the PSTs' opinions about the use of the discrepant events in science classroom were asked in the second application. PSTs expressed their thoughts as a group after small group discussions about the possible effects, positive and negative aspects of using the discrepant balloon activity in science classroom. The codes obtained from the analysis of PSTs' answers are given in Table 4.

Table 4. PSTs' opinions regarding the use of the discrepant event

Codes	Groups
21st-century skills	G1, G2, G4, G5, G8, G10
Eliminating misconceptions	G3, G4, G9
Cooperative learning	G2, G4, G8

Research -Inquiry- Curiosity	G1, G4, G5, G7, G8
Conceptual and permanent learning	G2, G3, G6, G7, G8, G9
Attitude and motivation	G1, G4, G8
Draw attention	G4, G7
Psychomotor skills	G7
Science process skills	G1, G2, G7

The opinions of some groups regarding the 21st-century skills code about the benefits of using the discrepant event in science education are as "*discrepant events should be used in science classes because they improve students' creative thinking skills, supports group work and collaborative work*" (G8), "*such activities enable students to come up with problem-solving, analytical thinking, critical thinking, creative ideas*" (G4), "*such experiments should be carried out because these experiments make the student active participants of the lessons and improve their innovation skills*" (G2).

The groups thinking that discrepant events would eliminate the misconception of the students expressed their opinions as "*these activities enable students to consolidate the concepts and eliminate misconceptions*" (G9), "*such activities can be used to arouse students' curiosity and eliminate misconceptions*" (G4).

Three groups have emphasized cooperative learning. PSTs in one of these groups expressed their thoughts as "*such activities should be used because they enhance collaboration in group work*" (G8).

Five groups stated that discrepant events would improve students' curiosity and some skills such as research and inquiry. Thoughts of some of these groups' are as "*such activities develop a sense of curiosity in students and improve research skills*" (G1), "*these types of events can be used in lessons. These activities improve creative thinking. It awakens a sense of curiosity*" (G5).

The majority of groups stated that discrepant events would provide conceptual and permanent learning. Some groups' views on this regard were as "*these activities need to be used in science lessons because students can learn conceptually because it is shown as an application*" (G6), "*such activities should definitely be included in science teaching. They enable students to learn meaningfully and permanently by doing and living*" (G7).

Some groups stated that discrepant events would increase students' attitude and motivation towards science lessons. Thoughts of some of these groups were as "*with such* *activities, students' willingness to learn increases*” (G4), “*we should do these activities because they increase students' positive attitudes towards science lessons*” (G8).

PSTs who thought that discrepant events could be used to draw attention expressed their thoughts as “*such activities should be included in science lessons because they draw students' attention*” (G7), “*such experiments can be used to draw students' attention to the lesson, to arouse curiosity*” (G4).

The PSTs in G7 stated that discrepant events could be used to develop psychomotor skills. Group members expressed their opinions as “*such activities should be included in science education. In this way, students’ psychomotor skills can be developed*” (G7).

Lastly, PST groups stated that discrepant events would improve students' scientific process skills. Some groups' thoughts on this were as “*students' prediction, observation, and interpretation skills can be improved*” (G1), “*we must provide students with scientific process skills. Therefore, such activities should be used*” (G2).

In the current research, regarding the possible benefits of using discrepant events in science education, all of the groups stated that it is beneficial to use discrepant events in science education. At this point, PSTs mostly emphasized that discrepant events can improve students’ 21st-century skills, provide meaningful and permanent learning, and improve students’ curiosity, research, and inquiry skills. Discrepant events are quite powerful tools that can be used to arouse interest, learn about misconceptions, and develop higher-order thinking skills (González - Espada et al., 2010). Therefore, PSTs’ expression that discrepant events will contribute to science education is an indication that they will include such activities in their classrooms in the future. In this way, they will be able to create learning environments in the future where their students can produce more qualified arguments, develop higher-level thinking skills, and evaluate the events from a critical and analytical perspective.

Conclusions and Suggestions

Results of this research showed that PSTs could not make high-level arguments to explain a discrepant event by using their physics and chemistry knowledge in the prediction phase. However, when they are provided with additional information that they can use to explain the discrepancy and well facilitated during argumentation, the quality and explanatory power of the arguments increased slightly. Finally, it was seen that PSTs have the opinions that using discrepant events would be beneficial in science education.

Based on the results, it can be suggested that PSTs should be exposed to different discrepant events or situations that create different cognitive contradictions during their university education. In other words, teaching environments where PSTs can create more qualified arguments for discrepant events should be created. In teaching method courses within the scope of teacher education programs in Turkey, the discrepant event should be used as a productive context in teaching some certain methods such as argumentation or inquiry based learning. Also, results of the study revealed that PSTs have difficulty in using their content knowledge to explain a scientific phenomenon. In order to support learners from all levels including university education, constructivist and learner centered teaching approaches should be adopted in science lessons. In this regard, students should face to real life problems they need to solve using their content knowledge. In this regard, use of discrepant events can be helpful. In addition, as a limitation of the current research, only one discrepant event is used to asses PSTs arguments. Additional researches implementing different discrepant events from different disciples can be conducted. Finally, it is recommended to conduct researches with students from different educational levels to develop competencies such as analytical and critical thinking, conceptual learning, and attitudes by using discrepant events.

Fen Bilgisi Öğretmen Adaylarının Sezgiye Ters Bir Olaya İlişkin Argümanları ve Bu Tür Olayların Fen Eğitiminde Kullanılmasına İlişkin Düşünceleri

Özet:

Bu çalışmanın amacı, fen bilgisi öğretmen adaylarının (FBÖA) sezgiye ters bir olaya ilişkin argümanlarını ve bu tür çelişkili olayların fen eğitiminde kullanımına ilişkin görüşlerini belirlemektir. Araştırmada nitel araştırma yöntemi desenlerinden araçsal durum çalışması benimsenmiştir. Araştırmanın çalışma grubunu Türkiye'de İç Anadolu Bölgesinde bulunan bir devlet üniversitesinin fen bilgisi öğretmenliği bölümünde okuyan 73 öğretmen adayı oluşturmaktadır. Araştırmanın verileri yazılı dokümanlar kullanılarak toplanmıştır. Araştırmada toplanan veriler betimsel analiz kullanılarak analiz edilmiştir. Analizler, fen bilgisi öğretmen adaylarının sezgiye ters olayla ilgili bireysel argümanlarının zayıf ve çelişkiyi açıklamakta yetersiz olduğunu göstermiştir. Fen bilgisi öğretmen adaylarına ek bilgiler sağlandığında, etkili bir şekilde işbirliği yapmaya teşvik edildiğinde ve grup olarak çalışmalarına izin verildiğinde ise argümanların kalitesi ve açıklama gücü artmıştır. Ancak öğretmen adaylarının ne bireysel ne de grup olarak çalıştıklarında üst düzey argümanlar üretemedikleri görülmüştür.

Anahtar kelimeler: sezgiye ters olaylar, fen eğitimi, argümantasyon, kimya eğitimi

References

Akbayrak, K., & Namdar, B. (2019) An argumentation activity for third-grade students: objects in the plates, *Science Activities, 56*(1), 1-10. https://doi.org/10.1080/00368121.2019.1600464

Altunışık, R., Coşkun, R., Bayraktaroğlu, S., & Yıldırım, E. (2010). *Sosyal bilimlerde araştırma yöntemleri: SPSS uygulamalı [Research methods in social sciences: SPSS applications].* Sakarya Publishing.

Anderson, C.. & Smith, E. (1983). Teacher behavior associated with conceptual learning. In *Proceedings of the Annual Meeting of the American 'Educational Research Association*, Montreal. Canada.

Appleton, K. (1996). Students' responses during discrepant event science lessons. In *Proceedings of the annual meeting of the National Association for Research in Science Teaching*, (ERIC Document Reproduction Service No. ED 393 696)

Bakioğlu, B., & Çevik, M. (2020). Views of science teachers on distance education during the COVID-19 pandemic. *Turkish Studies, 15*(4), 109-129. https://dx.doi.org/10.7827/TurkishStudies.43502

Barron, B. (2000). Problem solving in video-based micro worlds: Collaboration and individual outcomes of high achieving sixth grade students. *Journal of Educational Psychology, 92*(2), 391 – 398. https://psycnet.apa.org/doi/10.1037/0022-0663.92.2.391

Blikstein, P., Fuhrmann, T., & Salehi, S. (2016). Using the bifocal modeling framework to resolve "Discrepant Events" between physical experiments and virtual models in biology. *Journal of Science Education and Technology*, *25*(4), 513-526. https://doi.org/10.1007/s10956-016-9623-7

Canbazoğlu, S., Demirelli, H., & Kavak, N. (2010). Investigation of the relationship between pre-service science teachers' subject matter knowledge and pedagogical content knowledge regarding the particulate nature of matter. *Elementary Education Online*, *9*(1), 275-291. https://dergipark.org.tr/tr/download/article-file/90808

Carlsen, W. S. (1999). Domains of teacher education. In J. Gess-Newsome and N.G. Lederman (Eds.), *Examining Pedagogical Content Knowledge*, (133-144). Kluwer Academic Publishers.

CoHE, (2018). New teacher training undergraduate programs. Retrieved from https://www.yok.gov.tr/kurumsal/idari-birimler/egitim-ogretim-dairesi/yeni-ogretmen-yetistirme-lisans-programlari

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

de Oliveira, M. H. A., & Fischer, R. (2017). Ciênsação: gaining a feeling for sciences. *Physics Education*, *52*(2), 025011.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science education*, *88*(6), 915-933. https://doi.org/10.1002/sce.20012

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). The effects of integrated problem-based learning, predict, observe, explain on problem-solving skills and self-efficacy. *Eurasian Journal of Educational Research*, *20*(85), 45-64. https://doi.org/10.14689/ejer.2020.85.3

FlinnScientific. (2012). *Discrepant balloons*. Retrieved from https://www.youtube.com/watch?v=W12k1sTw-do.

González-Espada, W. J., Birriel, J., & Birriel, I. (2010). Discrepant events: A challenge to students' intuition. *The Physics Teacher*, *48*(8), 508-511. https://doi.org/10.1119/1.3502499

Harteis, C., Goller, M., and Caruso, C. (2020). Conceptual change in the face of digitalization: challenges for workplaces and workplace learning. *Frontiers in Education. 5*(1), 1-10. https://doi: 10.3389/feduc.2020.00001

Hewson, P. W., & Hewson, M. G. B. (1984). The role of conceptual conflict in conceptual change and the design of science instruction. *Instructional Science*, *13*(1), 1-13. https://doi.org/10.1007/BF00051837

Hiğde, E., & Aktamış, H. (2017). Examination of pre-service science teachers' argumentation-based science lessons: case study. *Elementary Education Online*, *16*(1), 89-113. http://dx.doi.org/http://dx.doi.org/10.17051/io.2017.79802

Hong, J. C., Hsiao, H. S., Chen, P. H., Lu, C. C., Tai, K. H., & Tsai, C. R. (2021). Critical attitude and ability associated with students' self-confidence and attitude toward "predict-observe-explain" online science inquiry learning. *Computers & Education*, *166*, 104172.

Ješková, Z., Featonby, D., & Feková, V. (2012). Balloons revisited. *Physics Education*, *47*(4), 392-398. https://doi.org/10.1088/0031-9120/47/4/392

Karamustafaoğlu, S., & Mamlok-Naaman, R. (2015). Understanding electrochemistry concepts using the predict-observe-explain strategy. *Eurasia Journal of Mathematics,* *Science and Technology Education*, *11*(5), 923-936. https://doi.org/10.12973/eurasia.2015.1364a

Kavogli, Z. (1992). Discrepant events: An alternative teaching process. *Science Education International*, *3*(3), 10-13.

Kızkapan, O. & Bektaş, O. (2021) Enhancing seventh-grade students' academic achievement through epistemologically enriched argumentation instruction, *International Journal of Science Education*, *43* (10), 1600-1617, https://doi.org/10.1080/09500693.2021.1923082

Limón, M. (2001). On the cognitive conflict as an instructional strategy for conceptual change: A critical appraisal. *Learning and instruction*, *11*(4-5), 357-380. https://doi.org/10.1016/S0959-4752(00)00037-2

Magnusson, S., Krajcik, J. & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome and N.G. Lederman (Eds.), *Examining Pedagogical Content Knowledge* (pp. 95–132). Dordrecht, Kluwer Academic Publishers.

Mancuso, V. J. (2010). *Using discrepant events in science demonstrations to promote student engagement in scientific investigations: An action research study.* Doctorate dissertation, University of Rochester, Rochester, New York

Mason, D., Griffith, W. F., Hogue, S. E., Holley, K., & Hunter, K. (2004). Discrepant event: The great bowling ball float-off. *Journal of Chemical Education*, 81, 1309-1312. https://doi.org/10.1021/ed081p1309

Mazur, E. (1997). *Peer Instruction: a User's Manual*. Prentice-Hall.

Nadelson, L. S., Heddy, B. C., Jones, S., Taasoobshirazi, G., & Johnson, M. L. (2018). Conceptual change in science teaching and learning: Introducing the dynamic model of conceptual change. *International Journal of Educational Psychology*, **7**(2), 151-195. https://doi.org/10.2196/resprot.2372

O'Brien, T., Stannard, C., & Telesca, A. (1994). A baker's dozen of discrepantly dense demos, *Science Scope*, *18*, 35–38.

Phelps, E., & Damon, W. (1989). Problem solving with equals: Peer collaboration as a context for learning mathematics and spatial concepts. *Journal of Educational Psychology*, *81*(4), 639-646. https://psycnet.apa.org/doi/10.1037/0022-0663.81.4.639

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, *66*(2), 211-227.

Sampson, V., & Clark, D. (2009). The impact of collaboration on the outcomes of scientific argumentation. *Science Education*, *93*(3), 448–484. https://doi.org/10.1002/sce.20306.

Sampson, V., Grooms, J., & Walker, J. P. (2011). Argument-Driven Inquiry as a way to help students learn how to participate in scientific argumentation and craft written arguments: An exploratory study. *Science Education*, *95*(2), 217-257. https://doi.org/10.1002/sce.20421

Sarah, S., Khanif, A., & Saputra, A. T. (2021). The effectiveness of POE (Predict-Observe-Explain) learning model for ımproving student analytical skills. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(1), 23-29.

Shemwell, J. T., & Furtak, E. M. (2010). Science classroom discussion as scientific argumentation: A study of conceptually rich (and poor) student talk. *Educational Assessment*, *15*(3-4), 222-250. https://doi.org/10.1080/10627197.2010.530563

Stake, R. E. (1995). *The art of case study research*. Sage Publications.

Schworm, S., & Renkl. A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology 99*(2), 285–96. https://psycnet.apa.org/doi/10.1037/0022-0663.99.2.285

Senemoğlu, N. (2010). *Development, learning, and instruction: From theory to application (17th edition).* Pegem Publishing.

Sinatra, G. M., Kienhues, D., & Hofer, B. K. (2014). Addressing challenges to public understanding of science: Epistemic cognition, motivated reasoning, and conceptual change. *Educational Psychologist*, *49*(2), 123– 138. https://doi.org/10.1080/00461520.2014.916216

Suprapto, N. (2020). Do we experience misconceptions?: An ontological review of misconceptions in science. *Studies in Philosophy of Science and Education*, *1*(2), 50-55. https://doi.org/10.46627/sipose

Taşçı, S. (2021). Evaluation of emergency distance language education: Perspectıves of elt students. *Nevşehir Hacı Bektaş Veli University Journal of Social Sciences Institute*, *11*(1), 286–300. https://doi.org/10.30783/nevsosbilen.877657

Toulmin, S. E. (2003). *The uses of argument*. Cambridge university press.

Vaughn, A. R., Brown, R. D., & Johnson, M. L. (2020). Understanding conceptual change and science learning through educational neuroscience. *Mind, Brain, and Education, 14*(2), 82-93.

Wright, E. L., & Govindarajan, G. (1992). Stirring the biology teaching pot with discrepant events. *The American Biology Teacher*, *54*(4), 205-210. https://www.jstor.org/stable/4449456

Yıldırım, A & Şimşek, H., (2011). *Qualitative research methods in social sciences*. Seçkin Publishing