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Chemistry Teachers' Level of Scientific Explanation about Change of State and their Beliefs about Scientific Explanation

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ABSTRACT The purpose of this study is to examine the capability of chemistry teachers' scientific explanation on the subject of change of state related to daily life and their beliefs about scientific basis. The sample of this study constituted forty-six chemistry teachers working at different high schools in Gaziantep. The study was conducted following the phenomenographic research method. Within the scope of the study, a test consisting of open-ended questions was conducted to determine the teachers' capability to make scientific explanations and their beliefs about scientific explanations. Study findings showed that the chemistry teachers participating in this study had inadequacies in making scientific explanations and that their beliefs about scientific explanations were unsatisfactory.

Keywords Chemistry education, Chemistry teacher, Science Education, Scientific explanation

1. INTRODUCTION

Chemistry is one of the disciplines that we use in our daily life throughout our lives. From the agents used in cleaning and hygiene works to the making of clothing, from the food industry to the manufacture of plastics, and from the fuel we use to elucidate criminal acts, we witness the use of chemistry in many fields. In addition, we frequently use chemical terms to explain the formation of acid rain and natural phenomena like snowfall. Besides, we use chemistry to describe some events we encounter daily. For example, it is possible to explain why the soda we buy from the supermarket tastes different when it is cold through the solubility of gases. Therefore, it is possible to say that chemistry is intertwined with our lives and has become indispensable for us; and that most of the subjects in chemistry lessons are related to daily life. One of the missions of educational institutions is to present the relationship between chemistry and everyday life to students from primary school to high school and university.

One of the essential objectives of science education is to teach science lessons making associations with daily life (Cajas, 1999). Besides, the students need to relate the phenomena to their knowledge for a meaningful learning process (Yilmaz & Çavas, 2006). For significant and permanent learning in chemistry lessons, it is known that it would be helpful for the students to use their chemistry knowledge when explaining the events and phenomena related to daily life (Yadigaroglu & Demircioglu, 2012). Therefore, it is vital to encourage the students to make explanations. As a result, students use different information and concepts when explaining various phenomena, and this helps students go through a meaningful learning process (McNeill & Krajcik, 2008). However, it is difficult for students to make appropriate explanations by themselves. So that students can improve their capability of explaining, teachers must be good role models for them at school. Therefore, it is considered that the explanations of teachers are important in order that the subjects of science lessons are comprehensible and permanent. Hence, especially in science lessons, teachers must explain the subjects related to daily life with causal reasons (Saglam, Karaaslan & Ayas, 2014), and students must be allowed to make explanations. In order to ensure this, it can be stated that teachers first must know what a scientific explanation is and how to make a good scientific explanation. No study was found in the literature that determines the teachers' beliefs about scientific explanations. In a study by Saglam, Karaaslan & Ayas (2014), primary school teacher candidates' beliefs about scientific explanations were determined. Thus, it is possible

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to say that the study is unique as it has determined high school teachers' beliefs.

Scientists and other people ask questions "why?" and "how?" throughout their life (Lombrozo, 2006). People answer such questions based on their positions. Also, science aims to explain a phenomenon or event by answering how and why it occurs (McNeill & Krajcik, 2008). Besides, the explanation is one of the main concepts frequently used in scientific research (Rockse'n, 2016). What is meant by this concept is a scientific explanation. But what is a scientific explanation? Unfortunately, it is impossible to give an exact answer to this question. Although some consider the scientific explanation as explaining the phenomena through several various methods (Grunberg & Grunberg, 2011), and some as information structured by scientists (Köseoğlu, Tümay & Budak, 2008), it appears that there is not only one definition in the literature regarding scientific explanation (Braaten & Windschitl, 2011; Saglam, Karaaslan & Ayas (2014). For example, according to Hempel (1965), a natural phenomenon must be explained based on specific laws.

On the other hand, Salmon (1984) emphasizes cause and effect relationships in an explanation to understand the world around us. On the other hand, Friedman (1974) and Kitcher (1989) emphasize that many other phenomena must be explained to explain a phenomenon. Rockse'n (2016) points to three potential meanings of the word 'explanation'. These are casual meaning, pedagogical/competence-related purpose, and scientific meaning. In the scientific meaning of explanation, there must be conditional and causal relationships between sequential events. At the same time, Braaten & Windschitl (2011) suggested a model that projects that observed natural phenomena, particularly, be explained by forming a logical causal relationship between established scientific facts.

Although the importance of scientific explanation, as well as the need for improving the students' capability of making scientific explanations, were emphasized (American Association for the Advancement of Science [AAAS], 2009; MEB 2013; National Research Council [NRC], 1996), in various studies, it was observed that students, teacher candidates, and teachers had difficulty in explaining the chemical phenomena related to daily life (Akgün, Tokur & Duruk, 2016; Dindar, Bektaş & Çelik, 2010; Yıldırım & Birinci Konur, 2014;).Moreover, with advancing technology, although visual and technological tools such as computerized animations, simulations, graphic materials, and laboratory studies are frequently used, these are not focused on scientific explanations (Gilmanshina, Gilmanshin, Sagitova & Galeeva, 2016).

It is observed that students are mostly asked to provide causal details and build relationships when explaining the questions asked when the studies on science education are reviewed, especially chemistry education (Herman, Owens, Oertli, Zangori & Newton, 2019). In other words, these explanations are expected to answer questions of "why" and "how" (Dindar, Bektaş & Çelik, 2010). Therefore, teachers expect students to build a causal relationship while explaining any event or phenomenon (Yadigaroglu & Demircioglu, 2012). But on the other hand, it is observed that students mostly make short definitions and cannot explain why they are asked to explain an event related to daily life (Demirbaş & Pektaş, 2009; Saglam, Karaaslan & Ayas, 2014).

As stated above, various studies showed that the students could not make adequate explanations. Therefore, it is thought that teachers first need to have sufficient background on this subject to fill this deficiency in the students.

This study aims to examine the high school chemistry teachers' capability of making scientific explanations on the subject of change of state related to daily life and their beliefs about scientific explanation. Therefore, answers were sought for this study's research questions: i) What is the high school chemistry teachers' capability level of making scientific explanations on chemistry subjects related to daily life (change of state)? ii) How are the beliefs of high school chemistry teachers about a scientific explanation?

2. METHOD

The phenomenographic research method, one of the qualitative research methods, was applied in this research. People can perceive and interpret the same events differently, even living in the same environment. Phenomenographic research is interested in people's different views and perceptions (Christensen, Johnson & Turner, 2011; Çepni, 2007; Trigwell, 2006). Phenomenographic research is focused on the phenomena we are aware of but do not have a detailed understanding of. In this research type, phenomena can appear as events, perceptions, beliefs, concepts, or situations (Yıldırım & Şimşek, 2013). The phenomenographic research method was used as the purpose of this study is to examine the high school chemistry teachers' capability of making scientific explanations on the change of state related to daily life, as well as their beliefs about scientific basis.

2.1. Participants

The study participants were determined by the criterion sampling method of purposeful sampling. Purposeful sampling allows for an in-depth study of situations that are thought to have rich information (Patton, 1997). The criterion sampling method studies situations that meet a predetermined set of criteria. Researchers can create the mentioned criterion or criteria. (Yıldırım & Şimşek, 2013). The criteria used in determining the sample in this study are as follows; teachers working from different high schools, experience (year), genders, and teachers must have taught the subject of change of state in the chemistry

Table 1. Demographics of the Study Sample

	Experience (years)						
Gender	1-5	6-10	11-15	16-20	21 Years and more	f	%
Female	6 FT2, FT10, FT11, FT17, FT20, FT24	3 FT7, FT19, FT21	2 FT22, FT23	7 FT1, FT3, FT9, FT12, FT13, FT15, FT18	6 FT4, FT5, FT6, FT8, FT14, FT16	24	52,2
Male	2 MT17, MT18	2 MT6, MT12	5 MT1, MT7, MT8, MT9 MT20	5 MT10, MT13, MT16, MT19, MT21	8 MT2, MT3, MT4, MT5, MT11, MT14, MT15, MT22	22	47,8
f	8	5	7	12	14	46	
%	17,4	10,9	15,2	26,1	30,4		

course during the year the study took place. In this respect, 46 chemistry teachers working at different high schools in Gaziantep participated in the study. Male teachers were coded as MT1, MT2..., and female teachers were coded as FT1, FT2…. The teachers' genders and experience (year) were given by frequency and percentage in Table 1. It can be said that the numbers of male (22) and female (24) teachers are very close and that the teachers with different years of experience were selected (Table 1)

2.2. Data Collection

The study aims to determine the high school teachers' beliefs about scientific explanation and their capability of making scientific explanations on chemistry subjects related to daily life. It was decided to prepare questions on change of state, which is related to daily life and has been taught since the first stage of education, to assess the capability of teachers. Then, teachers were asked questions about melting, one of the changes of state phenomena, to determine their capability of making scientific explanations. For this purpose, the teachers were asked two open-ended questions to collect data. In preparing open-ended questions, Turkey's high school chemistry curriculum and contents were considered. To determine whether open-ended questions are suitable for teachers, the opinions of two associate professors and professors, who are science educators, were consulted. A study by Karaaslan (2014) was used to prepare the questions. It took approximately 6-10 minutes for the teachers to answer the questions. The questions are given below.

1. What do you think "Scientific Explanation" means? Can you explain?
2. Uğur saw his mother melt a piece of butter in the pan while cooking. Uğur is curious about knowing how this change in the butter occurs. Could you please scientifically explain to Uğur how this phenomenon occurs?

2.3. Data Analysis

The first question was analyzed to determine teachers' beliefs about scientific explanations, and the second was analyzed to identify their capability to make scientific explanations. When analyzing the first question, the statements emphasizing the cause-and-effect relationship in teachers' explanations were regarded as the expected explanation. On the other hand, when analyzing the second question, the teachers were expected to almost make a story out of the events within the frame of cause & effect relationship, and such explanations were regarded as the accepted scientific explanation (Braaten & Windschitl, 2011; Saglam, Karaaslan & Ayas, 2014).

In the analysis of the first question, the deductive analysis method (Patton, 2002) was used. This study compiled and used the codes and categories created by Saglam, Karaaslan & Ayas (2014). From this point of view, teachers' answers were read a few times, and similar statements were gathered under the same code. Then, these codes were gathered under the defined categories (Miles, Huberman & Saldaña, 2018). After the codes and categories were creat ed, the definitions of each code (Table 2) were created using the teachers' explanations (Saglam, Karaaslan & Ayas, 2014). The code definitions are given in Table 2.

The analysis determined two categories and seven codes, as seen in Table 2. To establish the reliability of the codes, the definition table and the explanations of 20 random teachers were given to two chemistry academicians. They were asked to code the teachers' explanations according to the definition table. At the end of the coding by the chemistry academicians, the reliability coefficient was calculated using the formula by Miles, Huberman & Saldaña, (2018).

$$\text{Reliability Coefficient} = \frac{\text{Number of agreements}}{\text{Total of agreements and disagreements}} \, x\, 100\%$$

As a result of the calculations, the reliability coefficient was determined as 87%. Therefore, a consistency percentage of 80% between the investigators' and coders' assessments is regarded as reliable (Cicchetti, 1994; Miles & Huberman, 1994).

Table 2. Table of definitions of teachers' beliefs about scientific explanation

1- Codes of Scientific Knowledge Category (Teachers' Explanation)	Definations of Code's (Teachers' Explanation)
a) Evidence based	This code includes following expression Explanations based on experiment or/and observations; should be done in labs; based on data/proof/reasons; explaining with examples; proved information;
b) Knowladge Level	This code includes following expression Listeners' suffcient knowledge level; explaining according to level of listeners'; presenter should have sufficient level of knowledge;
2- Codes of Explanation Category (Teachers' Explanation)	**Definations of Code's (Teachers' Explanation)**
a) Authorized	This code includes following expression Explaining by using specific terms/expressions/cocepts; explaining with information based on literature; concepts are explained; explaining terminologically
b) Scientific explanation	This code includes following expression Explaining the phenomenons/problems in reason-result relationship; explaining by expressing the reasons and whys
c) Reasonable	This code includes following expression Explaining the phenomenons reasonably; explaining persuasively
d) Intelligible	This code includes following expression; Using clear and understandable expressinos; explaining objectively
e) Other	This code includes following expression Explaining systematically

Table 3. Rubric for determining the teachers' capability of making scientific explanations

Points	Not Explanation (0 Point)	Inadequate Explanation (1 Point)	Scientific Explanation (2 Point)
Properties of Explanation	A description made without providing any theoretical component or an incorrect explanation made or related premises presented tangentially without forming a story.	Explaining made from the beginning and causative links made to the subsequent premises, but at least one premise is missing in the story.	-Explaining made from the beginning and causative links made to the subsequent premises and the premises presented within a complete story.

In the second question of the study, to determine the teachers' capability of making scientific explanations, the analysis was made using the rubric prepared by Saglam, Karaaslan & Ayas (2014). Accordingly, the rubric, which was prepared by taking the expert opinions of two science academicians, was given in Table 3.

The rubric and the explanations of 20 teachers were given to two chemistry academicians, who were asked to grade the teachers' explanations to establish the grading reliability. For grading, the reliability was calculated by calculating the Kappa coefficient within the SPSS package. If the Kappa coefficient is between 0.81 and 1.00, then there is a perfect consistency (Landis & Koch, 1997). The fact that the calculated Kappa coefficient is 0.93 shows that there is an ideal consistency.

3. RESULT

3.1. Teachers' Beliefs About Scientific Explanation

To determine the teachers' beliefs about scientific explanation, they were asked 'What do you think "Scientific Explanation" means? Can you explain?' In the definition table, the codes indicating each teacher's explanation and examples of teachers' explanations for the codes are presented in Table 4.

Looking at Table 4, it is seen that most of the explanations of the teachers are included in the evidence-based code. For example, scientific explanation is the "Explanations based on scientific data, observations, and experiments," according to FT3. Thus, the explanation of this teacher was included in the evidence-based code. Again, as MT12 perceived scientific explanation as "explaining an existing phenomenon based on scientific facts", the explanation of this teacher was included in the same code.

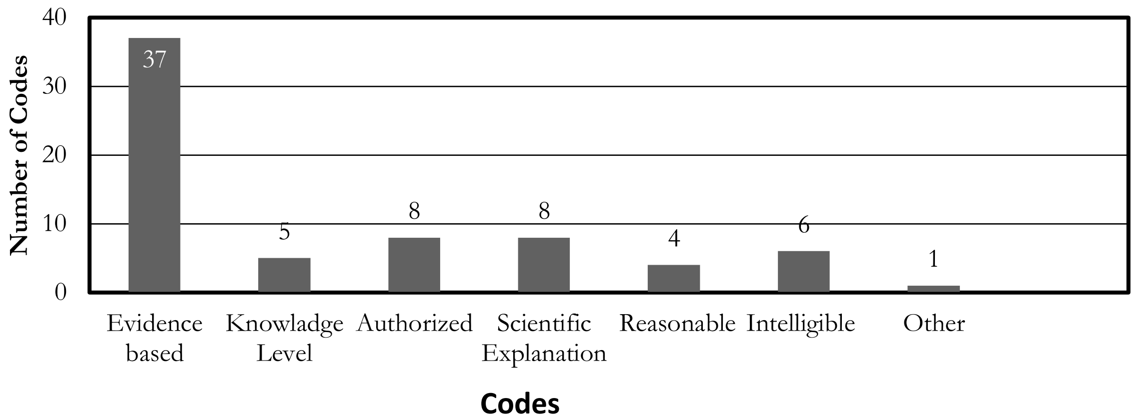

Figure 1. Teachers' beliefs about scientific explanation

The teachers' explanations of the cause & effect relationship were included in the scientific explanation code. Looking at the table above, it is observed that eight of the explanations of the teachers were included in the scientific explanation code. For example, it is seen in Table 4 that explanations such as "It means explaining the events and phenomena that occur in nature within the scope of cause & effect relationship suggested by science. (MT8)", "It means explaining the causes of the events around us with their reasons (FT23)" point to the cause & effect relationship.

Figure 1 shows how many times each code is repeated. Looking at Figure 1, it is seen that there are 69 codes in total. The reason for this is the fact that some teachers' explanations are included in more than one code. According to the Figure, 53% (37 statements) of all the codes (69 codes) are included in the evidence-based code, 7% (5 statements) are included in the knowledge level code, 12% (8 statements) are included in the authorized code, 12% (8 statements) are included in the scientific explanation code, 6% (4 statements) are included in the reasonable code, 9% (6 statements) are included in the intelligible code, and 1% (1 statement) are included in the other code. According to this information, it is seen that only 12% of all the codes have statements to be included in the scientific explanation code.

Viewing the explanations of the teachers (Table 4), which were included in the scientific explanation code, based on the demographic properties (Table 1), it is seen that, of female teachers, FT1 has 16-20 years of experience, FT14 has more than 21 years of experience, FT21 has 6-10 years of experience, and FT23 has 11-15 years of experience; of male teachers, MT1 and MT8 have 11-15 years of experience, MT10 has 16-20 years of experience, and MT17 has 1-5 years of experience

3.2. Teachers' Level of Scientific Explanations

To determine the teachers' level of scientific explanations, they were asked the following question; "Uğur saw his mother melt a piece of butter on the pan while cooking. Uğur is curious about know how this change in the butter occurs. Could you please scientifically explain to Uğur how this phenomenon occurs?" The scientific explanation expected from the teachers for this question must be;

- ✓ *The heat flows from the pan, the temperature of which is higher, to the butter, the temperature of which is lower.*
- ✓ *As the kinetic energy of the particles of the heated butter increases, they start to move faster.*
- ✓ *Fast-moving particles get away from one another, and the distance between the particles starts to increase.*
- ✓ *In this way, the butter in the solid state melts, changing into a liquid state.*

Or a similar explanation (Karaaslan, 2014).

According to the rubric, the level of the teacher's explanations and the example explanations of the teachers for each level are given in Table 5.

Figure 2 shows the total number of teachers included in each grading type based on the teachers' explanations.

Looking at Figure 2, it is seen that 25 teachers (55%) were given 0 points as their explanations were not regarded as scientific, 14 teachers (30%) were given 1 point as their explanations were scientifically inadequate, and seven teachers (15%) were given 2 points as their explanations were regarded as scientific.

Reviewing the teachers with scientific explanations (Table 5) based on their demographics (Table 1), it is seen

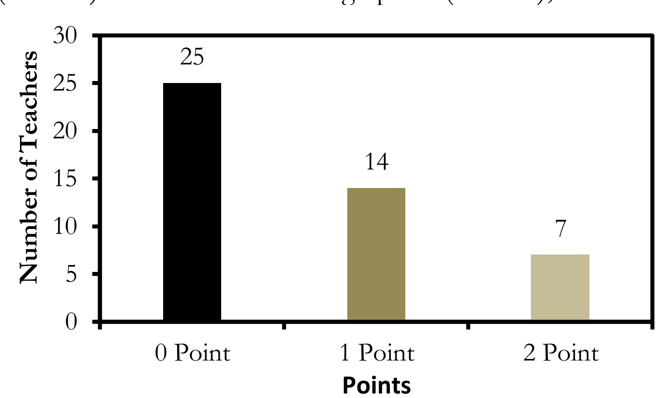

Figure 2. Distribution of the explanations of the teachers based on rubric

Table 4. Examples of teachers' explanations

1- Codes of Scientific Knowledge Category	*Examples*
a) Evidence based FT1, FT3, FT4, FT5, FT6, FT7, FT8, FT9, FT10, FT11, FT12, FT13, FT14, FT15, FT17, FT18, FT19, FT21, FT22, FT24, MT1, MT2, MT3, MT4, MT5, MT6, MT7, MT9, MT11, MT12, MT13, MT14, MT16, MT18, MT19, MT20, MT22	*Explaining based datas, observations and experiments…(FT3)* *…are explanations based on experienced informations…(FT5)* *…explanations with some examples in science. Explanations based on evidences…(FT11)* *…explaining based on certain reasons…(MT2)* …explaining a phenomenon based on reasons…(MT12)
b) Knowladge Level FT2, FT3, MT1, ET2, MT11	*…while making scientific explanation, the level of knowledge should be sufficient (FT2)* *…listeners' knowledge level should be sufficient, too…(FT3)*
2- Codes of Explanation Category	**Examples**
a) **Authorized** FT16, FT20, FT22, MT1, MT6, MT14, MT20,MT21	*Explaining process by using the expressions which science uses to explain phenomenon happening in nature. (FT16)* *…explaining by using appropriate concepts and terms…(MT1)* *…explanations based on information in literature…(MT6)* *…terminologically explaining procces…(MT14)* First, cocept are defined…(MT20)
b) Scientific Explanation FT1, FT14, FT21, FT23, MT1, MT8, MT10, MT17	*Explaining the reasons of any phenomenon (FT14)* *…explanations that totally based on reason – result relationship (FT21)* *Explaining the incidents around us with their reasons. (FT23)* Explaining the incidents and *phenomena happinig in the nature in scientific reason – result relationship (MT8)*
c) Reasonable FT1, FT4, FT14, FT16	*...persuasive, satisfactory explanations…(FT1)* Explaining the incidents *happinig in the nature in a reasonable way (FT4)*
d) Intelligible FT7, FT14, FT16, FT21, MT15, MT16	*…explaining without any personal comment…(FT7)* *…explanations that are different from daily speech. (FT21)* *Simple explanations are important…(MT16)* It is a kind of explanation that your listener can understand (MT15)
e) Other MT21	*Rule and laws have been explored. When we explain an incident scientifically, we express this rule and law. (MT21)*

that, of the female teachers, FT16 has more than 21 years of experience, FT17 and FT24 have 1-5 years of experience, and FT18 has 16-20 years of experience; and of the male teachers, MT8 has 11-15 years of experience, and MT16 and MT21 have 16-20 years of experience.

Considering the demographic properties of the teachers (Table 1), it is seen that eight male teachers with more than 21 years of experience did not make any explanations e ligible for being included in the scientific explanation code (Table 4) and could not make any complete scientific explanations (Table 5).

4. DISCUSSION

The first question of the study aims to determine the teachers' beliefs about scientific explanations. Viewing the results obtained from the analysis of this question, it was concluded that most teachers perceived scientific explanations as explanations based on scientific experiments or evidence. F or example, it was determined that FT3 perceived scientific explanation as "Explanations based on scientific data, observations, and experiments", and likewise, MT2 perceived scientific explanation as "Explanations based on specific foundations and facts". Furthermore, in a study on candidate form teachers by Saglam, Karaaslan & Ayas (2014), it was determined that the majority of the candidate teachers perceived scientific explanations as explanations based on specific evidence, data, experiments, and observations.

Considering the studies in literature, it is stated that subjects or events especially related to daily life must be explained by emphasizing cause & effect relationships (Braaten & Windschitl, 2011). However, in the study, it is

Table 5. Teachers' capability level of making scientific explanations and example explanations

Points	*Not Explanation (0 Point)*	*Inadequate Explanation (1 Point)*	*Scientific Explanation (2 Point)*
Properties of Explanations	FM2,FT3, FT4, FT5, FT6, FT7, FT8, FT10, FT12, FT13, FT14, FT15, FT19, FT20, FT22, FT23, MT2, MT3, MT4, MT7, MT10, MT15, MT17, MT18, MT20	FT1, FT9T, FT11, FT21, MT1, MT5, MT6, MT9, MT11, MT12, MT13, MT14, MT19, MT22	FT16, FT17, FT18, FT24, MT8, MT16, MT21
Teacher's Examples	*- First of all, butter changes from solid to liquid. At the same time there is chemical changes in the form of the butter. Since unsaturated fat rate falls, moleculer structure have been spoiled. (FT3)* *- Thanks to heat, it gives the container of the butter electrons fast. Heat melts the butter by triggering the electrons that butter contains. (FT5)* *- Butter melts and the water in it evaporate. (FT8)* *- Matter turns from solid to liquid by getting heat. (FT22)* *- Because of heat, butter starts to melt. (MT18).*	*- Solid matter changes into liquid when they get heat. When we put the butter in a pan and heat it, interaction among moleculs decreases and the matter changes its form. (FT21)* *- When the solid matters get heat, the gravitational force decreases and the form changes. (MT6)* *- Butter is a solid matter, and when the solid matter gets heat, the gaps among molecules increases. (MT12)*	*- The energy of the molecules in butter increases. Hance the molecules get away from each other, and the butter turns into liquid. (FT17)* *- Between the substances which has different temperatures, there is a heat enrgy flow from the hotter one to the colder one. The heat energy increases the speed of particles of matters, so the gravitational force among the particles of the matter decreases. The paricles whose the gravitational force decreases get away from each others and becomes liquid then gas. (MT8).*

seen in Table 4 that only eight teachers emphasize cause & effect relationships when making scientific explanations. Thus, it is possible to say that the teachers' beliefs about scientific explanations are inadequate. Therefore, it is thought that the fact that the studies made, especially on the national level, regarding what scientific explanation is and how it should be made are limited, and that the exams for transition to secondary education and higher education are made in the form of tests, and that teachers teach lessons aimed at these exams (Demir & Demir, 2012) affects their insufficient understanding of scientific explanation.

The second question of the study aims to determine the teachers' level of scientific explanations. In the explanations, it was observed that some teachers mostly made definitions when scientifically explaining the melting phenomenon. For example, the explanation of FT22, "Matter changes into the liquid state from the solid state when heated." is regarded as the definition of the melting phenomenon. Again, the explanation of MT15 is as "Solid matter increases its temperature and changes its state when it gets heat from outside. In other words, it changes into a liquid state from a solid state when it reaches a definite temperature. That is why the butter changes into a liquid state from a solid state." can be regarded as a definition. The terms description and explanation must not be confused because description and explanation are two different terms (Horwood, 1988). The difference between these two terms can be exemplified using the freezing phenomenon. It is possible to state that saying liquid matter changes into the solid matter by losing heat (emphasizing the observed qualities) is making a definition while explaining the freezing phenomenon by expressing various theories and laws, such as gravitation between particles and particle movements of liquid matter losing heat within the frame of cause & effect relationship is making a scientific explanation. Again, considering the results of the second question of the study, it was determined that some teachers made incorrect explanations. For example, FT5 said, "The butter rapidly gives electrons to the pan due to the heat. And it activates and melts the electrons inside the butter", explaining the melting phenomenon as giving electrons. She was given 0 points due to her non-scientific explanation. Therefore, it was concluded that the teachers were incapable of making scientific explanations regarding the change of state related to daily life. Reviewing the conducted studies, it is seen that teacher candidate or teachers make incorrect or inadequate explanations in chemistry subjects related to everyday life (Alameh, El-Khalick & Brown, 2022; Boyraz, Hacıoğlu & Aygün, 2016; Saglam, Karaaslan & Ayas, 2014; Uluçınar Sağır, Tekin & Karamustafaoğlu, 2012; Yadigaroglu & Demircioglu, 2012). Most of the studies in the literature point to incorrect explanations or misconceptions of events rather than their scientific explanations (Yakmaci-Güzel, 2013; Yavuz & Büyükekşi, 2016)

It is seen in Table 5 that some teachers were given 1 point as they had missing parts in their explanations to the second question of the study. For example, as MT6 did not point to the kinetic energy and particle movements in his explanation, "When the solid matter is heated, gravitation between molecules decreases and the change of state occurs", he was given 1 point. On the other hand, seven teachers' explanations were regarded as complete scientific explanations, so they were given 2 points. For example, as MT8 said, "Between the objects with different temperatures, energy called thermal energy is transferred from the hot object to the cold object, and the thermal energy increases the movement speed of the particles which form the matter; therefore, gravitation between the particles of the heated matter is weakened. The particles with weak gravitation move away from one another to change into a liquid state, and then a gaseous state."; it is possible to say that he made a complete scientific explanation. Because MT8 explained the phenomenon within the frame of the cause & effect relationship, it is considered that teachers must adequately present the differences between the definition and scientific explanation. It can be suggested that teachers mostly make definitions when making scientific explanations because they lack knowledge of how to make a proper explanation (Karaaslan, 2014). The inability to adequately associate scientific concepts and explanations when explaining a phenomenon makes it difficult for teachers to construct scientific explanations (Polat, 2022). Moreover, it is considered that teachers teaching a lesson based on rote learning rather than explaining an event or phenomenon in detail (Nakiboğlu, 2009) may prevent them from making scientific explanations.

For teachers or candidate teachers to make adequate scientific explanations in chemistry subjects related to daily life, they first should know what a scientific explanation is and how it must be made because an effective scientific basis makes it easier for the students to learn the concepts and enables them to understand these concepts thoroughly (Coleman, 1998). Moreover, the literature emphasizes that providing students with subjects related to daily life increases their motivation (İlhan, Yıldırım & Sadi-Yılmaz, 2016; Kutu & Sözbilir, 2011). Therefore, it is assumed that addressing chemistry subjects related to daily life following scientific explanation rules may support their success in chemistry lessons.

It is proposed that teachers' detailed explanations, including causal relationships and encouraging students in this respect, may increase students' success in international exams such as PISA and TIMSS. Because, it was observed that the success level of our students was relatively low, especially in the questions requiring explanation in the said exams (MEB, 2016). Similarly, the studies conducted in our country showed that the students were incapable of making scientific explanations; in other words, their explanations for the open-ended questions were short and inadequate answers that did not contain any causal relationships (Akgün, Tokur & Duruk, 2016; Saglam, Karaaslan & Ayas, 2014; Yadigaroglu & Demircioglu, 2012).

Considering the relationship between the teachers' opinions of scientific explanation and their years of experience, out of 14 most experienced (21 years and above) teachers, only FT14 pointed to the cause & effect relationship. Therefore, the explanation of FT14, "Explaining the causes of any event," was included in the scientific explanation code. Thus, it is possible to say that there is not any positive relationship between the teachers' years of experience and their beliefs about scientific explanations. Again, looking at the relationship between the teachers' capability of making scientific explanations and their years of experience, it was determined that, of the most experienced teachers, only FT16 made a complete scientific explanation and that the other teachers could not make a thorough scientific explanation. From this point of view, as the explanation of FM16, "…There is little space between fat molecules in the solid state. Molecules apply gravitational force on one another, and the matter exists in a solid state. When the same matter receives thermal energy from outside, the kinetic energy of the molecules increases and the bond that maintains the gravitation between the molecules is broken, so the movement of the molecules increases. Therefore, molecules move away from one another, and the matter begins to change into a liquid state…" this was a complete scientific explanation. Therefore, she was given 2 points. From this point of view, it may be concluded that there is no positive relationship between the teachers' capability to make scientific explanations and their years of experience.

When both international and national studies were reviewed, no study determined the teachers' beliefs about scientific explanations. However, international literature decided that there was just one study on candidate teachers (Saglam, Karaaslan & Ayas, 2014). Thus, it is thought that it would be useful to research to determine chemistry and other science teachers' beliefs about this notion and to make up for their deficiencies.

5. CONCLUSION

As mentioned above, various studies demonstrated that students could not make scientific explanations. In this study, it was concluded that teachers' competence levels in this subject were unsatisfactory. From this perspective, it is considered that giving teachers some courses or training regarding scientific explanation would be useful both for themselves and the students.

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