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An Investigation of Concepts about “Gases” through Didactic Transposition in Higher Education

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Abstract

Didactic transposition theory examines the development from scientific / academic knowledge being produced by scientists to it becoming learned knowledge constructed by learners. According to the theory, four kinds of knowledge exist: scientific knowledge, knowledge to be taught, taught knowledge and learned knowledge. In this study, learning and teaching processes and the transition between different types of knowledge were investigated in detail for the concept of ―Gases” in higher education General Chemistry-I courses. The study was designed as a qualitative case study. Data were collected by lesson observations, semi-structured interviews, the Diagnostic Form and Word Association Test. The results revealed that the didactic preferences of the instructors were highly effective in influencing taught knowledge. It was additionally observed that the ―knowledge to be taught” of the instructors affected ―the taught knowledge,” and that the learned knowledge of the pre-service teachers was closely connected to ―taught knowledge” with individual characteristics. It can be concluded that the interaction between the instructor and pre-service teacher positively affected the learned knowledge of pre-service teachers. It was also found that pre-service teachers' pedagogical content knowledge and hidden curricula are effective for taught and learned knowledge.

Introduction

The twenty-first century world is becoming increasingly globalized, with significant implications for every aspect of human life. In the current system, it is necessary to train individuals who can respond to the needs of globalization. Knowledge helps support production in the process of industrialization, and with globalization, knowledge itself has become a factor that determines production power and the rate of capital accumulation. Therefore, a knowledge-producing industry (Arslanoğlu, 2002) has emerged in contemporary societies. When individuals are exposed to knowledge, they do not receive it directly. They make sense of knowledge according to their own cognitive structures. This knowledge is absorbed through different forms of transformation within each individual. Knowledge depends on the understanding of knowing (Özden, 2005). Therefore, in order to train individuals with desirable characteristics, the nature of the knowledge taught in schools is related to assimilation rate and how they assimilated. Considerable scientific knowledge is produced by scientists. At any level, this knowledge needs to be delivered to individuals through education. However, the transmission of such scientific or academic knowledge may cause individuals to struggle to make sense of it.

Therefore, knowledge must be transformed before being transferred to individuals. The theory that deals with this process is called ―*Didactical Transposition (DT) Theory*" (La Théorie de la Transposition Didactique). Chevallard (1985) described didactical transposition theory as ―all of the transformations that a knowledge has had as far as being a learned knowledge." DT is the theory that studies how the knowledge produced in research spheres are transformed and consolidated in knowledge to be taught both in higher education as in the educational basic cycle (de Mello, 2020). According to Bosch, Chevallard and Gascón (2005), didactical transposition theory essentially examines four types of knowledge and the transition between them. The first type of knowledge is called ―***scientific knowledge***," comprising the results of scientific research accepted by the scientific community. The second type of knowledge is called ―***knowledge to be taught***," and includes knowledge about the curriculum and information used by a teacher to prepare a lesson plan. The knowledge taught occurs within a relationship between three subjects: teacher, students and knowledge. These relationships are determined by the teaching methodology used (de Mello, 2020*)* ―***taught knowledge***," referring to the knowledge that the teacher uses to interpret the knowledge to be taught and to use it in context. In transitioning from *"knowledge to be taught"* to *"taught knowledge,"* the teacher has a say. Several factors affect the teacher's transposition. These can be grouped into internal and external variables. Examples of internal variables include the teacher's training in education (science, physics, chemistry, having graduated from fields such as biology) and professional experience (years of work) can be given as examples. External variables include the success rate of the school's primary entrance examination and attitudes towards these exams. Brousseau (2011) admits the existence of a system of interactions, but identifies other factors interacting in the system: the material and school environment and the educational system, as strong factors. It also indicates two more discrete factors: the interaction between the system and the student / learner person. The student person, in interaction with the rules of the education system; and the person (the same) of the learner, as a subject who interacts with the teacher and knowledge (Aristides, 2018, as cited in de Mello, 2020).The fourth type of knowledge is called ―*learned knowledge",* which is that configured by students.

As Bosch and Gascón (2006) have stated in their work pertaining to the field of mathematics, one of the basic aims of the didactic transposition theory is to make it clear that it is not possible to interpret school mathematics in a comprehensive way without considering the events related to mathematical knowledge originating from mathematical information producing institutions. Knowledge is produced universally, but as Brousseau (2002) states that as a result of the interactions between student, teacher and knowledge, the remaining part of the student is accepted as the knowledge learned in this study. Moving from this, learned knowledge is only considered meaningful if it is linked to scientific knowledge. In this sense, the importance of the relationship between the knowledge produced by scientists and the knowledge absorbed by the student, as well as the transposition process between the two groups clearly emerges. This transposition process has several stages, and there are many factors that work at each stage. In this context, it is crucial that this study consider the transposition process of scientific knowledge as much as it is absorbed by the individual, in terms of the three most important dimensions of this process: knowledge, teaching staff and student dimensions.

The work carried out in the last thirty years has shown; chemistry concepts are handled at different levels by teachers and students (Çetin, 2009, p: 25). Moving from here, it is thought that the didactic transposition is of considerable importance in understanding chemistry topics that contain numerous abstract concepts, so that they can become knowledge absorbed by the student. The main purpose of this study is to examine the didactic transposition processes of the identified concepts. Examination of the didactic transposition processes of the relevant teaching staff and pre-service teachers on the subject of “Gases” represents an appropriate focus, as it could constitute a source for teaching staff in the process of content creation.

According to Kuhn (2006), all scientific data and theories have been developed in advance and are often integrated with the paradigms of the community of science at the time in which they are written. Kuhn suggests that scientific resources must be renewed subsequent to every scientific revolution. Indeed, the development of scientific information is also realized in this way. If scientific information is exposed to such changes, it is necessary for the education systems to adapt to these changes and to ensure that the ***scientific knowledge*** produced is transformed until it becomes ***learned knowledge***. The present study is significant as the first to examine the didactic process of transposition of chemistry knowledge in higher education in Turkey. “After educators, textbook writers, and decision-makers in education departments decide what should and should be taught in the classroom, it is up to the teacher to decide how these norms and content will be effectively operationalized in the classroom (de Mello, 2020, p:3).” Therefore, examining pre-service teachers’ processes of transposition of knowledge can lead to the identification of possible problems or difficulties. At the same time, acknowledgment of the factors that affect the process of knowledge transposition can serve to reorganize higher education programs. In this sense, this study is important in terms of providing feedback to higher education systems.

According to the didactic transference theory, knowledge has a different meaning in every context. Therefore, this study, which aims to determine how teacher differentiation and teacher training program differentiation will affect the didactic transfer processes of knowledge, is thought to clarify the transformation process of knowledge. The vast majority of the work conducted in this area has compared different textbooks and curricula (as cited in Kaya & Ergun, 2012; Clément & Carvalho, 2007; Drakopoulou, Skordoulis & Halkia, 2005; as cited in Yıldırım, M., & Şahin, F. (2009a); Grosbois, Ricco & Sirota, 1992; Kang, 1990). The studies outside thereof; based on the analysis of didactic transposition processes and conceptual misconceptions of certain concepts in different disciplines. Analyses of concepts are generally at the level of pre-school, primary or secondary education (Banegas, 2014; Bulut Atalar, 2013; Güngör, 2009; Güngör & Özgür; 2009; Herrera, 2015; Kaya & Ergun, 2012; Komis, 2001; Masi & Santi, 2016; Pelitoğlu, 2006; Puig & Jimenez-Aleixandre, 2011; Quessada & Clément, 2007; Vellopoulou & Ravanis, 2012; Yıldırım, 2008; Yıldırım & Şahin, 2009a, 2009b; Yurdatapan & Şahin, 2012; Zogza & Papamichael, 2000). The didactic preferences of teachers in these processes have also become a subject of interest to researchers. A single study at the level of higher education exists (Kurnaz & Sağlam Arslan, 2009), and merely focuses on concept analysis and student knowledge. In this sense, a substantial gap exists in the literature that the present study seeks to fill. The intention is to examine the didactic transposition processes of the concepts at the level of higher education in depth, and to reveal the current situation in terms of didactic transposition processes in higher education in line with the stated aims. For these reasons, the aim of this study is examination of the didactic transposition processes of the knowledge that teaching staff and pre-service teachers possess regarding “Gases” under two different conditions. In the first stage, a General Chemistry-I course is conducted by two different teaching staff in two different groups in a science teacher education program, and in the second stage a General Chemistry-I course is conducted by the same instructor in two different groups in a primary teacher education program and science teacher education program.

For this purpose, the following questions were explored:

1. What constitutes instructors’ “knowledge to be taught” for the concepts about “Gases”?
2. What are the factors that are effective in selecting the concepts to be included in the course content of “Gases” in the instructors’ “taught knowledge” dimension?
3. What constitutes instructors’ “taught knowledge” about “Gases”?
4. What is the “learned knowledge” regarding “Gases” of pre-service teachers attending the General Chemistry-I course?

Method

Research Design

The research was conducted as a qualitative case study. Given that the didactic transposition process related to “Gases” in the General Chemistry-I course has been studied in depth, the investigation will include all of the individuals involved in the transposition process. The study was conducted in two stage and three steps. The first stage was to examine the didactic transposition processes in terms of two teaching elements in General Chemistry-I courses in two different sections of the same program. The second stage was to examine the didactic transposition processes in General Chemistry-I lessons conducted by one of the same instructors in two different programs. The following three-step process was conducted in order to examine both dimensions. In order to determine the *knowledge to be taught* at the first step, the concepts held by the instructors regarding “Gases” were determined. To this end, semi-structured interviews were first held with the instructors, and their didactic preferences and the reasons behind these preferences were sought.

Document analysis was also undertaken with the sources that instructors stated had helped them in their lessons. In the second step, the instructors’ lectures on “Gases” were observed and content analysis was undertaken in order to determine the *taught knowledge*. In addition, semi-structured interviews were conducted with pre-service teachers so that learned knowledge could be identified. The third step was to ultimately identify pre-service teachers’ *learned knowledge*. At this step, the Diagnostic Form and Word Association Test was administered to participants as a pre-test, post-test in order to ascertain their present knowledge, and learned knowledge about “Gases.” The diagnostic form implemented consisted of open-ended questions. At the end of the process, semi-structured interviews were conducted with participants to determine how the pre-service teachers underwent didactic transposition.

Participants

The participants comprised two instructors working in the Faculty of Education at a public university, specifically the departments of Science Teacher Education and Primary Teacher Education. Thereafter, the instructors are referred in the text as TS1 and TS2. TS1 has a PhD degree from department of chemistry and had 7 years teaching experience in primary education and 8 years in higher education. TS2 has a PhD from department of chemistry education at faculty of education and had 3 years teaching experience in higher education. In addition, pre-service teachers attending these teacher education programs participated. Two instructors were teaching General Chemistry-I courses in two programs, one containing 43 pre-service science teachers and the other one 20 pre-service primary teachers.

Data Collection Tools

Given that the research is a qualitative case study, document analysis, observation and interview techniques were used for data collection. Observation, diagnostic form, word association test and interviews with teaching staff and pre-service teachers were determined as data sources. The researcher developed data collection tools related to the mentioned techniques.

Observation

Unstructured observations were undertaken in the study. Course observations were recorded by video camera. Video recordings were performed using two cameras placed both in front of and behind the classroom.

Diagnostic Form

The diagnostic form was developed from open-ended questions in order to determine the knowledge of participants about gases. While this form is being formulated, it is aimed to prepare related questions, which will enable to have a deeper knowledge about the concepts defined in the word association test. For this purpose, the literature was searched and six open-ended questions as used in some previous studies (Çetin, 2009; Yalçınkaya, 2010) were included in diagnostic form.

Word Association Test

Six key concepts were identified for the Word Association Test (WAT) used in the study. These comprised concepts in the subject that were considered most important. During the selection of the concepts, two field experts were consulted. Key concepts used in the study included Gas, Real Gas, Ideal Gas, Gas Law, Kinetic Theory and Diffusion.

Prior to the application, explanations were made to the WAT and examples were given from different applications. For each concept, students were given 45 seconds. During these periods, students wrote down the words that they thought were related to the key concept. In order for the students to allocate equal time for each key concept on the test, the next key concept is presented after the time has expired. Each key concept was written across a single page in order to mitigate the risk of writing chained-answer words.

Interview

In this study, semi-structured interviews with the instructors were conducted to obtain data on *knowledge to be taught* and *taught knowledge*. Semi-structured interviews with prospective teachers were also conducted to obtain data on *taught knowledge* and *learned knowledge*. Interviews were held with the instructors before the instruction and with the pre-service teachers afterwards. First, draft interview forms were prepared and submitted to expert opinion. Following the experts' feedback, the interview forms were finalized. The selection of pre-service teachers to be interviewed was based on Student Selection Examination (SSE) scores for the program. Eighteen teacher candidates with high, medium and low levels were identified from each group. The rationale for using the SSE scores instead of the undergraduate achievement scores in the selection of pre-service teachers was that they were attending the first class. The data collection process is presented in Figure 1.

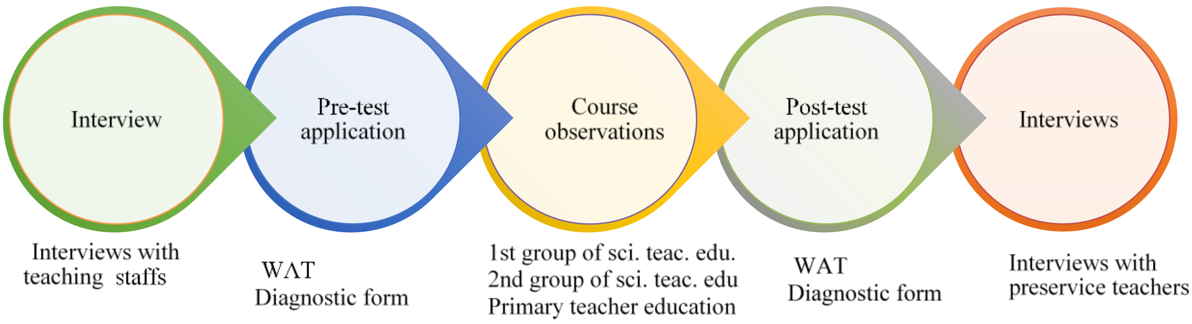

Figure 1. Information on the Data Collection Process

Data Analysis

In order to analyze the data attained, document analysis and content analysis techniques were used and an inductive analysis was performed. In the analysis of the interviews, the voice recordings were first transcribed. In the second step, researcher read the interview transcripts one by one, and open coding was performed. For the observational data, the same process as that for the analysis of the interview data was carried out, and following the coding process, inductive content analysis was performed.

Inductive content analysis was performed in the analysis of open-ended questions in the diagnostic form. In the analysis of the data obtained from the Keyword Association Test, a qualitative data analysis program was utilized and an analysis of the data was performed by the cut-off point technique developed by Bahar et al. (1999). According to this technique, the responses given to each key word were examined in detail, and the cut-off point was determined according to the frequency of responses by determining the answer word with the greatest frequency.

Validity and Reliability Studies

In order to increase the validity and reliability of the research, the research process was described in detail and the experts were consulted in all processes of the research. Moreover, the data were diversified using data collection techniques such as observation, interview and document analysis. The findings obtained as a result of the collection and analysis of the data were reported in detail and the obtained findings were described without interpretation. Direct quotations were supported with visual items; moreover, to prevent data loss, interviews were recorded using a voice recorder and observations were recorded with a video camera. In order to increase the validity of the observations, the researcher was present in the classroom during the observations to interact for a long time and took notes along with the video recording.

Findings

Findings Related to the Analysis of the Knowledge to Be Taught

Teaching staff 1's (TS1) *knowledge to be taught* in general about gases included definition of gas, vapor-gas difference, gas laws, ideal gas equation, and real gas systems. With regard to the interview, TS1 stated his views on the desirable knowledge of candidate teachers regarding gases, and what should be included as content:

> *"... attending chemistry teacher education or science teacher education do not notice in general chemistry level for the definition of the gas, the difference from the gas, the derivation of the ideal gas equation from the gas law, then whether these gas equations can be applied to the real systems, how can it be discussed and corrected for real systems? (TS1, Interview, October 9)."*

Document analysis of the source books that TS1 indicated he has used was carried out. Most of the concepts related to gases in Books 1 (B1) and 2 (B2) are similar. Nevertheless, it can be seen that in B1, the characteristics of the gases are considered in much greater detail, while in B2 only the basic characteristics of the gases are included.

When teaching staff 2's (TS2) *knowledge to be taught* is examined, the subjects concerning —Gases" she considers important include the behavior of gas particles according to solids and liquids, movements of gas particles, kinetic theory, gas laws, gas pressure, and atmospheric pressure. When asked whether she uses different resources for Science Teacher Education and Primary Teacher Education, TS2 answered as follows:

> —*.I. use the same book for the same main branch of Science, but at the level of classroom teacher, college-level books are too much for them, so I tell them to look at high school books or even junior high school books. I usually say them that "If you look at high school books and there is something you do not understand, you can lower your level to secondary school level" (TS2, Interview, October 8).*

She also states that she has benefited from the same sources in the primary teacher education program, but she teaches the concepts more simply. A document analysis of the source books used by TS2 was conducted. On examination of the concepts pertaining to –Gases" in Book 3 (B3) and 4 (B4), both books almost overlap in terms of the concepts underlying the gases. Only regarding real gases can B4 be considered as providing information that is more detailed.

Findings Related to the Analysis of Taught Knowledge

According to the results of the analysis of the course observations performed, it is seen that the taught knowledge about TS1 contained four categories (see Figure 2).

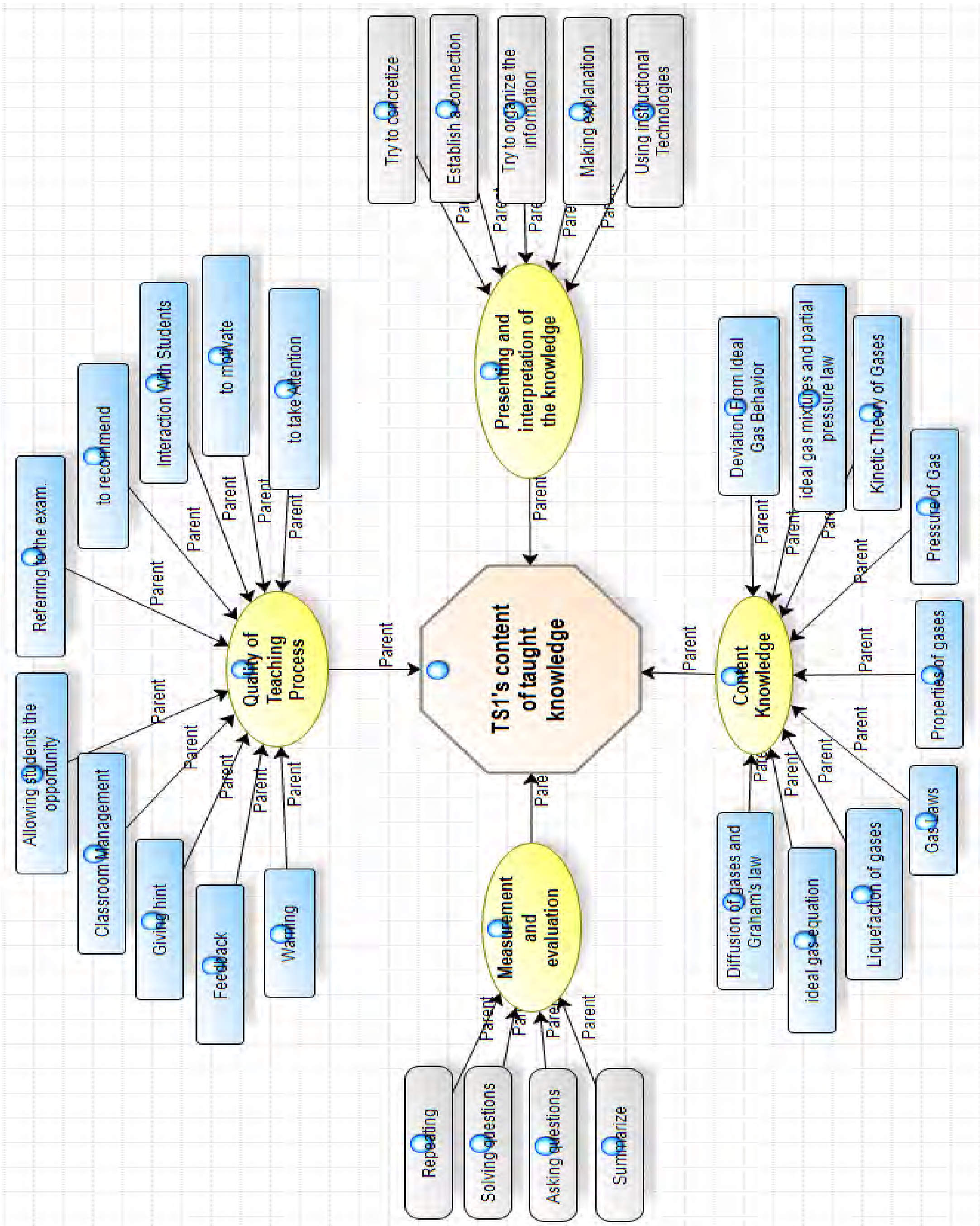

Figure 2. Categories and Subcategories Related to *Taught Knowledge* of TS1

The categories of *taught knowledge* comprise presentation and interpretation of knowledge, quality of teaching process, measurement and evaluation, and content knowledge. When the category of ―presentation and interpretation of knowledge" is examined, it would appear that TS1 has used the boards quite often (f: 53), but also the models (f: 14) and calculator (6), while the projection device (4) largely seems to be avoided as a means of teaching technology. The reason for this preference was explained as follows:

> *―I do not know how nice the drawing is, but I'm doing especially it, because I want to see that you are drawing it, too... or, I can show you the photo by using this (showing the computer) and then this (showing the projection device). You are drawing with me, are you? hah…" (TS1, Interview, November 2).*

When the category ―Qualification of teaching process" is examined, it can be seen that the instructor often addresses students using their names or posing a trick question. According to this finding, it can be stated that the instructor constantly tries to keep the students interested in the lecture, and places particular emphasis on concepts related to gases. The following quotation is illustrative:

> *―... R unit is connected to the pressure. If you use pressure as atmosphere, it is 0.0082 liters of atmosphere / mole kelvin; if you use pressure as pascal, by using newton/meter^2 formula, we can proceed to calculation… (TS1,Observation, November 9).*

It was determined that TS1 occasionally refers to the test used for the pre- service teachers to be appointed when they graduate. When B1 and B2 are examined, it is seen that the characteristics of the gases are generally emphasized in detail. When analyzing the category of content knowledge of the *thought knowledge* that emerged as a result of the analysis of the observations carried out in TS1's lessons, one important finding is that he highlights the pressure of gases but does not provide excessive detail regarding the ―properties of the gases." Regarding the pressure of the gas, the concepts it contains overlap with the concepts in B2. However, TS1's emphasis on the pressure units is an indication of his benefiting from B1 in the *taught knowledge* phase.

Overall, when the relationship between *knowledge to be taught* and *taught knowledge* is examined, it is seen that in the sources that TS1 stated as being *knowledge to be taught*, very detailed information was provided, yet the instructor did not offer as much complexity.

According to the results of the analysis of the course observations, it was seen that the *taught knowledge* by TS2 was also collected under four categories (see Figure 3). Six subcategories were identified in the category ―presenting and interpretation of knowledge," the analysis result of the course observations conducted to determine the *taught knowledge* by TS2. TS2 mostly made ―explanation for concept teaching" (f: 23). The important point here is that she rarely carries out explanations for the solution of the questions, while she often makes it to the explanation of the concept teaching. TS2 used the projection device (f: 15) and the whiteboard (f: 2) as instructional technology and frequently made connections with ―previous information (f: 5)" and ―daily life (f: 5)." However, ―interdisciplinary links (f: 2)" are given little space and the ―nature of science (f: 1)" is only emphasized once. The most striking finding of the analysis of the observations made is that the instructor verbally expresses all kinds of information, including mathematical knowledge (f: 4), without distinguishing the type of knowledge in question. The category “Quality of teaching process” consists of seven subcategories. The final category is “Measurement and Evaluation".

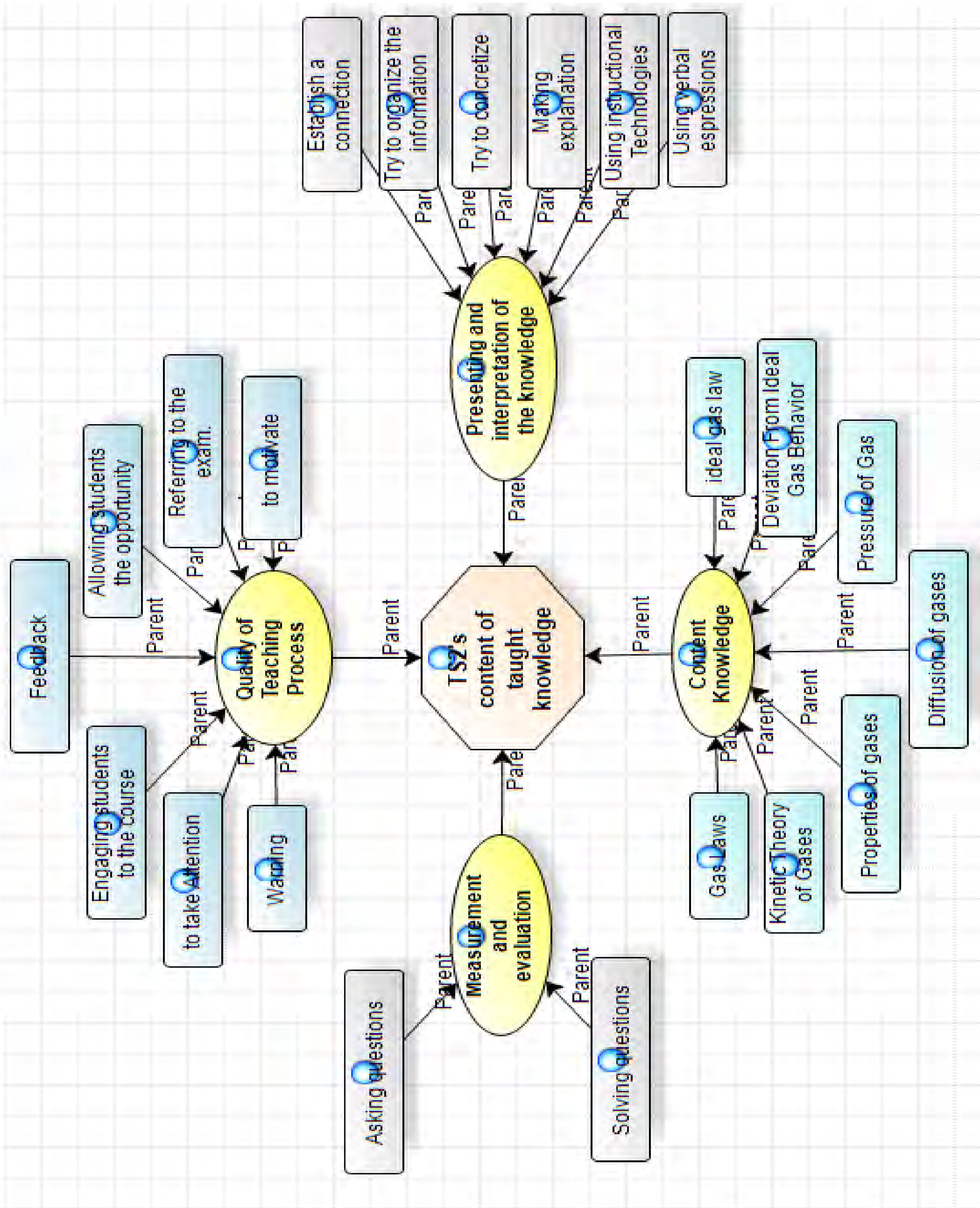

Figure 3. Categories and Subcategories Related to *Taught Knowledge* of TS2

When this category is examined, it can be seen that the instructor frequently asks students “thought- oriented” questions rather than “application-oriented” questions, and mostly answered “her own question”. In light of these findings, it may be that students often struggled to answer the questions and so the lecturer answered them herself. The last category is “*Content knowledge*.” When B3 and B4 are examined in the “knowledge to be taught” dimension for the Science Teacher Education program, it seems that both sources have similar contents and that the effect of these resources on the dimension of “*Content knowledge*” of the “*knowledge to be taught*” of TS2 is also quite high. For example, instructor, gives more space to the pressure of the gas within the overall properties of the gas as it has been presented in the content source. As a result of the analysis of the course observations and of the sources mentioned as *knowledge to be taught*, it can be seen that almost the same concepts as the diffusion of gases and deviations from the ideal gas hypothesis are included in the content.

According to the analysis of TS2's General Chemistry-I course observations in the primary teacher education program; the *taught knowledge* by TS2 is again collected under the same four categories. When these categories are examined, it is seen that TS2 tends to use the (f: 15) projection device as the teaching technology in the primary teacher education program in the category of “presenting and interpretation of knowledge.” According to the observations, the projector was used in various ways, ranging from presenting to watching relevant videos. She did not use the table very often. TS2 makes explanations most “for concept teaching (f: 13)” and least “for reasons (f: 1)” and “special situations.” The most striking finding here is that TS2 frequently describes mathematical expressions. This is thought to be due to the fact that this group does not have adequate infrastructure as stated in her interviews. One of the categories obtained from the content analysis of the TS2 course observations is the “Quality of teaching process.” It has been found that the instructor often alerts students (f: 9) about situations that require attention. It has been determined in the primary teacher education program that the instructor tries to motivate the students by encouraging their students (f: 4) or by simplifying subjects for students (f: 3). This situation is thought to be caused by TS2's desire for students to change their negative attitudes towards the course. TS2 tried various methods to motivate her students, but could not provide the same diversity in feedback and correction. She gives feedback to the students only by answering the questions they ask. It is remarkable that the only interactions that occur with the students are when she asks them questions. It is possible that this is due to the indifference of students to the course. It is an interesting finding that TS2 frequently uses drilling questions (f: 6), preliminary information questions (f: 6) and course attendance questions, which may be related to the profiles of the students in the group. When the findings pertaining to the content knowledge category are examined, the real gas and ideal gas concepts are not mentioned, and the ideal gas assumption is also overlooked. This may be because the teachers who graduated from the primary teacher education program will not have to teach chemistry. TS2 expressed her view on this subject as follows: *“...the chemistry lesson for primary teachers is less in content...however because of the fact that the students' Science background is very weak and their attitudes are very low and their relevance is also very low ımmm the content has to be even less.” (TS2, Interview, October 9).* When the relationship between TS2's *knowledge to be taught* and *taught knowledge* is examined, it can be seen that B3 and B4 have similar contents in the *knowledge to be taught* dimension for the Science Teacher Education program.

The impact of these resources on the content knowledge dimension of the teaching staff's knowledge is also quite large. When this situation is examined in the primary teacher education program, it seems that the concepts that the lecturer included in the content are quite simplified in terms of gases. Therefore, it is observed that the *taught knowledge* in the primary teacher education program differs from the *knowledge to be taught*. Accordingly, the content of *knowledge to be taught* and *taught knowledge* for TS1 differs too. In order to determine the reasons for this difference, a semi-structured interview was conducted with the instructors with the aim of identifying the factors that affect content preferences. The results of the factors that are effective in content selection are presented in Table 1.

Table 1. Content Analysis Results on Factors Affecting Instructors' Content Selection

Categories	Subcategories	TS1 f	TS2 f
Student Profile	Student performance	3	6
	Readiness Levels	2	1
	Student Attitudes	1	2
	Expectation Level	-	1
Content Knowledge Competence	General Chemistry Competence	4	-
Student Needs	Necessary Exam for Appointment	3	1
	Occupational Use Status		3
Benefited Resources	General Chemistry Books in Universities	1	-
	TCHE (Turkish Council of Higher Education) Draft Curriculum	1	-
	General Chemistry Books Translated from Foreign Books	-	2
	Expert Help	-	1

When the factors affecting the content preferences of the instructors are examined, it can be seen that similar categories generally appeared. All of the teaching staff stated that student level, readiness levels and attitudes towards the course are important factors in selecting the content. However, there are also interesting and striking differences. The content preferences of TS1 and TS2, who give the same lessons in the same undergraduate program, are separated from each other in terms of the resources they use. TS1 examines the TCHE draft curriculum and the resource books that are taught at universities, and makes content choices. It is thought that the reason for this is to capture a certain standard. TS2 states that he made content choices by examining the resource books he found meaningful and credible, as well as by referring to the opinions of an expert. While TS1 indicated that the exam that is a condition for appointment is particularly important in selecting content, TS2 has indicated that exam is effective, but also she frequently emphasized that the usefulness of knowledge in the profession is more effective in selecting content. The most noteworthy point here is that the content of a bachelor's degree program is determined for the exam that pre-service teachers have to pass after graduating.

Findings Related to the Analysis of Learned Knowledge

Learned Knowledge of Pre-service Science Teacher

The finding of the applied Word Association Test (WAT) analysis in the first group, in which TS1 was the instructor, shows that the answer, which is ―distance between particles", determines the cut- off point with a frequency of ten. Thus, the cut-off point is set to seven, and the concepts related to this response frequency form the first part of the concept network. Thereafter, response frequencies were reduced at certain intervals, and concept networks were created for the other intervals. When concept networks are examined, only four keywords were seen as being at cut-off point 7 and above. All key concepts appear to have emerged only at the final cut-off point. However, it is noteworthy that the relationships between key concepts are very weak in this range. In order to clarify the *learned knowledge* of the pre-service teachers in the first group, a post-WAT was applied. When the post- test data were analyzed by cut-off point technique, the concept determining the cut-off point became ―Guy-Lussac’s law,” with a frequency of 11. The cut-off point was set to nine according to the frequency of the response, and other cut-off points were determined by decreasing by 4 each time. When the concept network is examined, it is seen that the connections related to the misconceptions do not exist when compared with the pre-test KIT. However, at this level because of they are used to expressing kinetic theory by formulas, it is thought that the pre-service teachers may perceive the concepts as tools that can be used to solve questions. In the first question of the diagnostic form applied in the first group, the opinions of the pre-service teachers about ―what is between the gas particles” were sought. The majority gave the answer ―gravitational force (f: 6)” and then the ―space (f: 6),” bonds (f: 2) and air (f: 1) responses, respectively. According to the results of the analysis of the answers given to this question in the post-test, 40% of the answers of the pre-service teachers were ―empty.” At this stage, the proton, neutron and electron took the place of the opinions of the pre-service teachers in the sense that there is air between the gas particles. There was no change in the views of AS11, who stated that there are bonds between gas particles, but AS10 changed knowledge to ―space.” No change was seen in the views of AS1 and AS2, who suggested that there was a gravitational force between the particles in the pre-test. However, in the pre-test, AS6 and AS12, who gave the gravitational force as a response, changed their response to the correct ―gap” answer.

The pre-test applied to the pre-service teachers in the second group taught by TS2, and was analyzed by cut-off point technique. The concept determining the cut-off point became ―movement.” The concept network obtained from the analysis by the cut-off point technique is shown in Figure 4.

At the third cut-off point (between 4-7), all of the key concepts can be seen and a relationship established between some. The real gas key concept that emerged at this cut-off point was only associated to the ideal gas concept. Participants established the relationships between the concept of volume and ideal gas equations. In addition, the same relationship was established between the concept of ideal gas and gas laws. The point that stands out here is that the gas key concept is associated with air by the pre-service teachers, and gas is primarily referred to the minds of prospective teachers by gas samples. This finding suggests that pre-service teachers lack an in-depth preliminary knowledge of gases. When analyzing the post-test WAT data, it is seen that all key concepts only appeared in the last interval. However, in this range only the direct relationship between the real gas and the ideal gas could be established. It is noteworthy that at this level the concept of temperature is associated with four key concepts. The concepts associated with the gas law key concept are mostly examples of gas legislation.

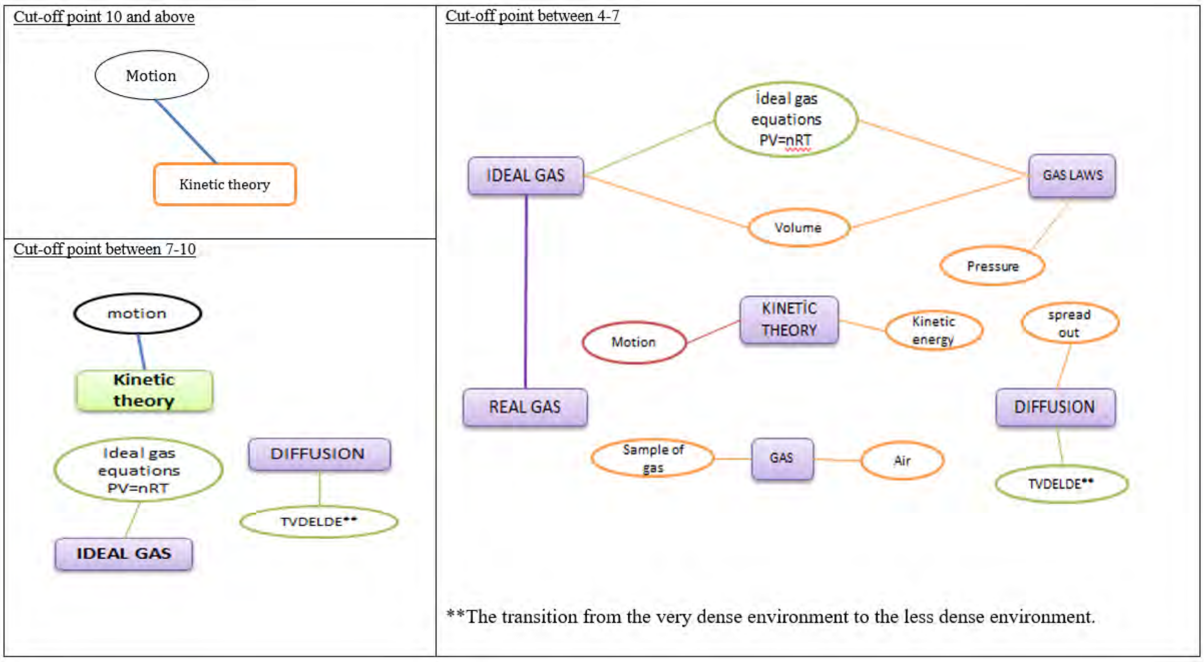

Figure 4. Concept Network of Pre-test WAT Analysis for the Second Group

Findings related to the analysis of the answers are given by the prospective teachers in the second question, which is included in the diagnostic form applied in the second group, as presented in Table 2.

Table 2. Frequency Table of Categorizations of Responses to the Second Question of the Diagnostic Form Belonging to the Second Group

Categories	**Pre-test** f	**Post-test** f
The pressure increases as the number of collisions increases.	8	7
According to PV = nRT formula; If the temperature increases, the pressure increases.	6	6
Pressure increases as the volume increases	5	5
As a result of filling the remaining spaces by gas, pressure increases	1	-

When Table 2 is examined, it is seen that the answers given to the diagnostic form in the pre-test and the post-test did not change to any great extent. Pre –Service teachers possess the knowledge both before and after teaching that when the temperature is increased in a closed container, the number of collisions of the particles will increase and thus the pressure will also increase. This information was preserved in the same way after teaching, without undergoing any transformation. BO1's answers to this question were as follows before and after instruction*: "Because the pressure increases as the gas temperature increases. When we heat the gases, the gas particles move away from each other and start to move, colliding with each other and applying constant pressure." (BS1, Pre-test diagnostic form). "Because the gases move fast as the temperature increases, they roughly apply pressure, which they multiply with each other" (BS1, Post-test Diagnostic form).* In addition to this scientifically correct knowledge, some teacher candidates (BS 3, BS 8, BS 15, BS 18 and BS 21) reported that the pressure would increase due to the increasing volume by temperature. Given these ideas, it is thought that they do not have any information about that ―volume change in a closed container will not occur" and ―volume increase will cause pressure reduction, not pressure increase."

Learned Knowledge of Pre-service Primary Teachers

The concept networks for the analysis of pre-test WAT data applied to pre-service primary teachers are presented in Figure 5.

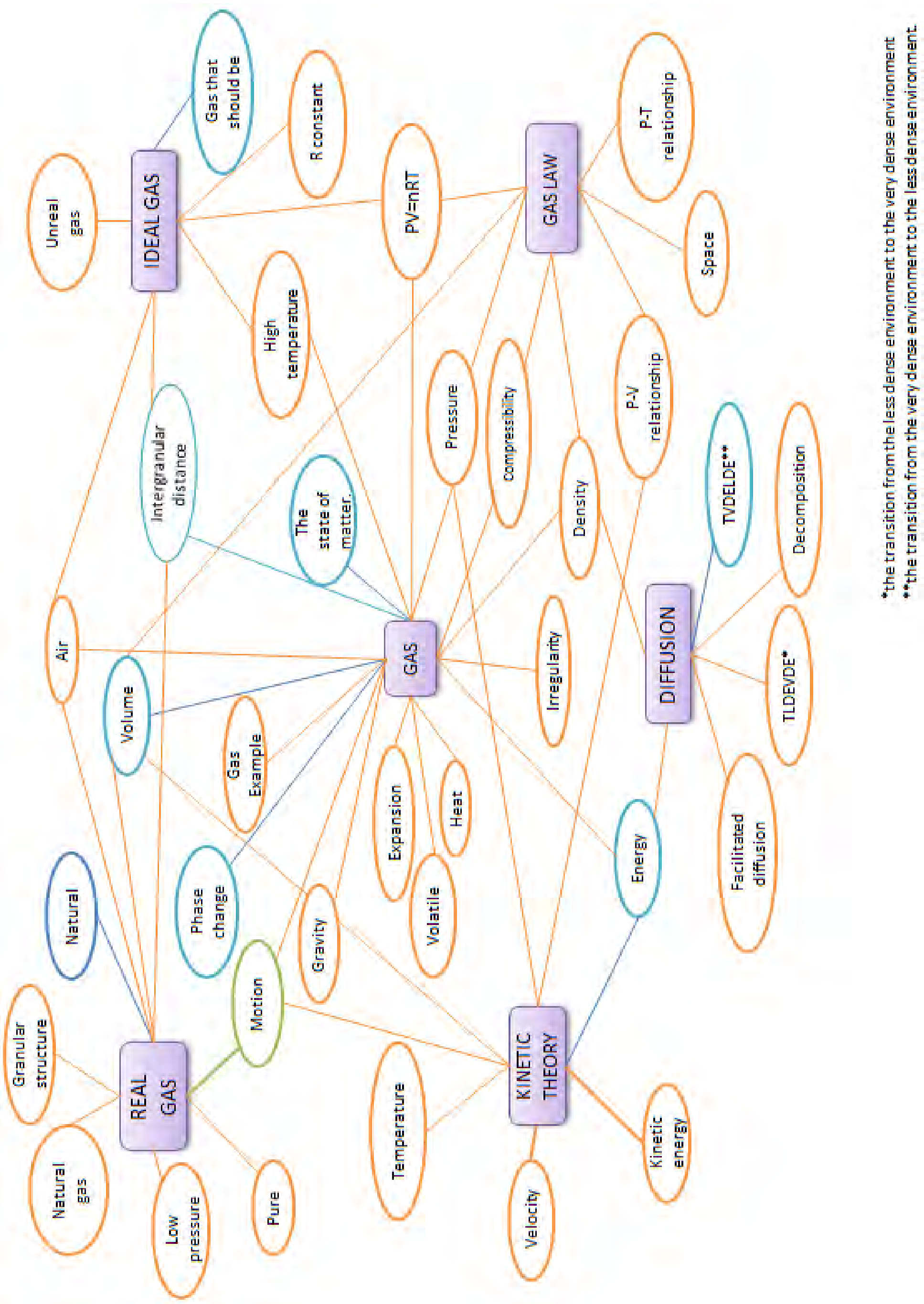

Figure 5. Pre-test of Pre-service Primary Teachers' Concept Networks of WAT Analysis

All key concepts emerged when the third cut-off point (1-3) was reached, but no direct relationship was established between them. The point that stands out here is that the gas key concept is related to the air by the prospective teachers, and when gas is mentioned, it first springs to mind that the gas samples and state change. This finding suggests that prospective teachers do not possess in-depth preliminary knowledge of gases; rather, it is superficial and general. According to the results obtained from the analysis of the post-test WAT data, it appears that all of the key concepts emerged when the third cut-off point (1-4) appears. However, it can be seen that direct relationships between key concepts that cannot be established in the pre-test might be established in the post-test. In the pre-test, the answers given to the concept of the gas law key did not reveal the names of any relevant scientists. In contrast, in the post-test it was seen that the respondents associated the gas laws with particular scientists. Moreover, kinetic theory was perceived as being related to the concept of collision. This finding is very important because it was not observed in any of the other groups. The findings of the analysis of the diagnostic form data of the pre-service primary teachers regarding the factors affecting the velocity of the gases are presented in Table 3.

Table 3. Frequency Table Regarding Categorizations of Responses to the Sixth Question of the Diagnostic Form of Pre-service Primary Teachers

Categories	**Pre-test**	**Post-test**
	f	**f**
As the temperature increases, the speed of the gases increases.	3	5
Gas with a small molecular mass is faster.	1	1
The type of the gas does not change its speed.	-	1

When Table 3 is examined, some classroom teacher candidates were already aware that temperature is a factor that increases the speed of gases (f: 3), but the ratio increased after teaching (f: 5). However, the most noteworthy finding here is that both before and after teaching, teacher candidates do not have the knowledge that gas is a factor that affects the speed of molecular masses. It has been determined that a large proportion of the teacher candidates answer the question at this point, but cannot explain it. When findings related to *taught knowledge* and *learned knowledge* are examined in general, it can be stated that not only the ―content knowledge” dimension of taught knowledge is effective for *learned knowledge*. It can be said that all dimensions including ―presentation and interpretation of knowledge,” ―the quality of teaching process” and ―measurement and evaluation” affect *learned knowledge.*

On examination of the *taught knowledge* content of TS1, who is teaching in the first group of the Science Teacher Teaching program, it can be seen that the lecturer possesses all of the methods and techniques to facilitate the understanding of the teacher candidates. Therefore, the *taught knowledge* of the TS1 may positively influence *learned knowledge*. On examination of the taught knowledge content of TS2, it can be seen that the individual attempts to embody the concepts, using the models, descriptions and analogies. In addition, the instructor largely uses the projector as a form of teaching technology, but seldom uses the whiteboard. The lesson observations conducted in the science teacher education program of TS2 also revealed that she only interacted with the pre-service teachers when using the question-answer technique.

Therefore, it would appear that a lack of situations enabling the transition from *learned knowledge* to *taught knowledge* would cause problems in the transposition stages. In this sense, it is thought that the impact of ―*taught knowledge*" of TS2 is minimal for the *learned knowledge* of pre-service teachers. The pre-service teachers expressed their perspectives as follows:

> *S17: I say, if the teacher is sitting and lecturing me from slides, I think it should not be so. It is restricting me. The teacher must be active in some way because if the instructor is active the students are also active in some way. Hmmm… activity must be at the forefront.*
> *Researcher: How is it?*
> *S17: In the form of a question-answer ... the teacher should not sit, stand or walk around. He can do it if he cannot do anything.*
> *Researcher: Do you want her/him to interact with the student?*
> *S17: Yes yes exactly. (S17, Interview, June 10).*

When TS2's *taught knowledge* in the other group of the primary teacher education program was examined, it appeared that she attempted to embody the concepts by using different teaching techniques, describing and giving examples in order that the students could visualize the concepts. Furthermore, some of the findings obtained from the *taught knowledge* analyses include the fact that she uses instructional technologies such as a projector, laser pointer and whiteboard. From the perspective of the characteristics of *taught knowledge*, it can be said that this will have a positive effect on the pre-service teachers' *learned knowledge*.

Discussion and Conclusions

It is evident that the instructors structured the content of the *knowledge to be taught* in the direction of the resource books they used. However, they simplified the content of what are detailed texts. Within the scope of *taught knowledge*, TS2 simplified the content more than did TS1, and preferred not to include some concepts or topics in the content at all. According to Yavuzsoy Köse (2016), teachers' content knowledge, pedagogical content knowledge, beliefs about education, language used, representations and cultural perspectives affect the transfer from *taught knowledge* to *learned knowledge*. In this context, the differences between the didactic preferences of the teaching staff may be due to demographic characteristics. For example, one of the most important factors affecting the didactic preferences of TS1, who holds a master's and doctoral degree in the Faculty of Arts and Sciences, is general chemistry competence. On the other hand, the didactic preferences of TS2, who completed the same levels of education in the Faculty of Education, is usefulness of knowledge in the profession. It is thought that TS1, who has background in the Faculty of Arts and Sciences, pays primary attention to the content knowledge competence. While the Factors influencing the content selection of TS1 are student profile, content knowledge competence, student needs and benefited resources. The factors that are effective in the content selection of TS2, which gives the same lesson in different undergraduate programs, are student profile, student needs and benefited resources. It has been determined that the resources that the lecturers use when developing the content of the *taught knowledge* are different. The resources used by TS1 are intended to conform to a certain standard. It could be concluded that the reason for this is the TS1's graduation from the Faculty of Art and Sciences, which aims to train scientists, where the subject matter information changes according to the grade level, not to the profession. As the reason of the didactic preference of TS2 in this direction, she is graduate of the Faculty of Education, aimed at teacher training, and so it is possible that she associates the concept of ―teacher" to the concept of ―interpretation of knowledge." However, the *taught knowledge has been* determined , by taking into account the ―conditional examination" and ―occupational use", in different groups. According to Kaya and Ergun (2012), teachers teach their students for success in the Level Determination Exam at middle school in order to enter high school. For this reason, the teachers at the two schools where the research is conducted also try to remain as closely as possible within the program. Moreover, Özgür and Pelitoğlu (2007) followed the course-building process of two science and technology teachers, and found that teachers used the knowledge that they deemed appropriate for national exam questions as well as curricula as references. The findings of this study accords with such results, especially the didactic preferences affecting *taught knowledge*. According to the findings of the present study, in the content preferences of the instructors, the ―*exam to be assigned to profession*" is an important variable, and so this finding accords with the needs of the society and the influence of educational philosophies to the development of curricula. Şahin and Kartal (2013) found that the content of a course was unrelated to occupation, among the factors that reduced the effectiveness of a course. This finding supports the didactic preference of the instructor in the study on the ―occupational use of concepts / subjects." Mouly et al. (1995) illustrate a distinction between *knowledge to be learned* and *learned knowledge*; indeed, each teacher is influenced by didactic work inspired by textbooks, professional experience, inspiration of the inspectors and the abilities of the students (as cited in Yildirim, 2008). Accordingly, Kaya and Ergun (2012) reinforce the findings of this study in that the use of differently *taught knowledge* in lessons taught by different teachers can result in a difference in *learned knowledge*. It has been determined that the *taught knowledge* in the three groups of the General Chemistry-I course consists of presentation and interpretation of knowledge, quality of teaching process, measurement and evaluation, and content knowledge categories. It has been determined that the *taught knowledge* by TS2 differs from TS1 in terms of providing content suitable for the student profile in the ―presentation and interpretation of knowledge" category. According to Vellopoulou and Ravanis (2012), teaching deals with the developmental needs and interests of students and the selection and adaptation of appropriate content to be taught in order to meet teaching objectives. This view supports the didactic preference of TS2 in providing content appropriate to the students' profiles. It is possible to treat the *taught knowledge* of teaching staff as pedagogical content knowledge. Shulman (1986) defined pedagogical content knowledge (PCK) as ―the ability of teachers to transform a given content knowledge (e.g., science) into a form of useful instructional presentation that can be adapted to students with different abilities and backgrounds." PCK provides a blend of pedagogy with content in understanding how certain topics, problems or topics are organized and presented, and how learners are adapted and taught in their skills and knowledge (Shulman, 1986).

In the study, the *taught knowledge* by the instructors was differentiated according to each other and groups. From this, it can be assumed that the reason for the differences in the *taught knowledge* of the instructors is due to the fact that the dimensions that constitute PCK are effective at different intensities. Moreover, the factors affecting the *taught knowledge* of TS2 comprise students' attitudes and levels of readiness, and instructors' expectations of them. Given that teacher candidates differentiate their attitudes in different groups, the content preferences of the instructors differ accordingly. Gabel's (1980) study of university students' attitudes towards science courses also revealed that students' attitudes toward science courses differ significantly according to their fields. In particular, it was concluded that the students of fields related to science were more positive than the others. Similar to this result, according to the studies of Hançer, Uludağ and Yılmaz (2007), pre-service science teachers have positive attitudes towards chemistry. TS2 particularly complained about the negative attitudes of classroom teacher candidates towards the lessons, and their inadequate science backgrounds. Studies conducted in the literature reflect this finding. In some studies, primary teachers expressed their negative attitudes towards science, and this was deemed by educators as constituting an obstacle to effective science teaching (Butzow, 1973; Jenkins, 1971 as cited in Bilgin & Geban, 2004; Loughran, 2007). In this sense, if instructors were to organize the contents of *taught knowledge* according to students' attitudes towards the lesson, the quality of the teaching will be improved. When the course observations are, evaluated TS1 was the more active in working with pre-service teachers. Knowledge basically comes from the process of interaction and communication (Polidoro & Stigar, 2010). In a study of instructors and lecturers seeking to determine the perceived effective teaching qualities of lecturers, Şen and Erişen (2002) indicated that effective lecturers should have mastered the subject knowledge and demonstrate a certain general culture. When the relationship between *taught knowledge* and *learned knowledge* is examined, it can be seen that the concepts that the instructors especially emphasize in the dimension of taught knowledge are better assimilated than the other notions. Teachers also determine by their own personal judgments, which subjects will be more significantly emphasized, and which lessons will be more important in a specific context (Sarı, 2007). According to Eisner (1985) as cited in Marsh (1997), the subjects that educators exclude from curricula are not less important than those that are included. Thus, the selection of what is more important and easy to understand is contingent on a teacher's personal perceptions. In this sense, pre-service teachers may be more effective at assimilating ―the knowledge that the instructor considers most important" because it is emphasized to them and taught more rigorously. In contrast, the concepts or topics not preferred by a lecturer may negatively affect the learning of other related concepts or topics. According to Yavuzsoy Köse (2016, p: 395), a teacher's judgments and interpretations of which information to use in the classroom and the textbooks and teaching materials to be used by students can affect ―*the learned knowledge.*"

Although the same lecturer conducts the same lesson in two different programs, differences can occur in all of the knowledge stages (*knowledge to be taught, taught knowledge, and learned knowledge*) due to the distinctive characteristics of the groups. Moreover, in the same teacher training program differences can emerge in the stages of knowledge that related to the differentiation of the teaching staff. Moving from this finding, it can be said that didactic transposition processes change according to different groups, different communities and different educational philosophies. Pelitoğlu (2006) suggests that the reason for the difference in misconceptions that have a didactic origin owes to difference in the choice of the *"knowledge to be taught*" references and therefore difference in, ―*taught knowledge*." That is to say, the difference in *knowledge to be taught* influences the *taught knowledge*. In Puig and Jimenez-Aleixandre's (2011) study of the contents of the *taught knowledge* in two different classes, it was concluded that significant differences in content knowledge and communicative approaches emerged between the two classes when the various dimensions were taken into consideration. In this sense, it can be concluded that didactic transposition processes should be evaluated in their particular context.

The most effective factor in the didactic transposition processes of knowledge in higher education is undoubtedly the teaching staff. The didactic preferences of the instructors are the most influential elements of this transposition process. This is because the didactic preferences of the instructors determine the formation of "*knowledge to be taught*" and "*taught knowledge.*" Although the determinants of *knowledge to be taught* at primary and secondary levels largely comprise program developers, Turkey lacks a standard curriculum in higher education and so the initiative belongs to educators. There is also no detailed curriculum for each course such as primary and secondary education in higher education. In general, every university determines the courses on offer, and the instructors who are put in charge of the course prepare the course description. However, during the "Restructuring of Education Faculties," first implemented in 1998, courses and curricula were decided by Higher Education Council of Country for each department at faculty of educations. However, these curricula do not include detailed explanations (Yüksel, 2002). According to the theory of didactic transposition, teaching in the classroom is shaped by mutually anticipatory expectations of teachers and students. Such mutual expectations and responsibilities, which together form a basic component of teaching, is called the didactic contract. In this sense, it would not be wrong to claim that the didactic contract corresponds to a kind of hidden curriculum in teaching.

According to didactic contract; a relationship is formed which determines —explicitly to some extent, but mainly implicitly— what each partner, the teacher, and the student, will have the responsibility for managing and, in some way or other, be responsible to the other (Brousseau, 1997). From here, it is thought that the hidden curriculum should not be ignored and that teaching environments should be regulated accordingly, in order that the didactic transposition process does not to come to a standstill. When the findings of the research are evaluated in general terms, it can be said that in higher education the didactic preferences of the teaching staff are vital at the "*knowledge to be taught*" and "*taught knowledge*" stages of the didactic transposition processes of knowledge regarding the subject of "Gases" in a General Chemistry-I course. In addition, when the relationship between *taught knowledge* and *learned knowledge* is examined, the didactic contract in the hidden curriculum between the teaching staff and the pre-service teachers is effective. Moreover, the PCK of the lecturer is determinative when the factors affecting the *taught knowledge* are considered separately. According to Shulman (1986), pedagogical content knowledge includes understanding what renders the learning of a specific subject easier and what makes it difficult. It is thus thought that in order to increase the effectiveness of curricula in higher education and to train teachers with the desired qualifications, the PCK of the instructors should be improved and importance should be attached to the hidden curriculum.

Note

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