ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

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To cite this article:

Anilan, B. & Berber, A. (2019). Effect of conversion factor on problem solving and experience of teacher candidates. *International Journal of Research in Education and Science (IJRES), 5*(1), 118-133.

IJRES International Journal of Research in Education and Science
Volume 5, Issue 1, Winter 2019 ISSN: 2148-9955

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Article Info

Article History

Received:
20 February 2018

Accepted:
14 August 2018

Keywords

Conversion factor
Chemistry education
Chemical calculation

Abstract

Through problem solving especially in the chemistry courses, individuals are required to solve difference types of problems both in traditional and innovative ways, and to reveal different points of views. Both correct results and correct units are achieved through the conversion factors. The fact that the teacher candidates approach problem solving processes through a different point of view is thought to contribute to the problem solving abilities of their students during their future professional lives. The object of this study is to determine the effect of use of the conversion factor, which the first class students of primary education science teaching department have experienced for the first time, on their success in problem solving, and the views of such students on the conversion factors. In this study, we have used the mixed design. As a result of the study, it is seen that problem solving abilities of the first class students of primary education science teaching department have increased thanks to the conversion factor method, which they have experienced in solution of some chemistry questions for the first time. And from the statements of the students, it is seen that the reasons for their having difficulty and failure are connected with applying a new method and insufficiency to organize the deficiencies and data in the basic science and mathematics infrastructures to be used by them during application.

Introduction

One of the basic objects of the education is to bring in the scientific process abilities that shall help the individuals learn new information by comprehending without memorizing and solve new problems by using the information learned before. One of the most important ways to ensure this is to establish cause and effect relationship. It is impossible to consider solution of any problems without having field information or scientific process abilities. Problem solving has been identified in many various ways. According to Wheatley (1984), problem solving is what you do when you do not know what to do, while according to Perez and Torregrose (1983), it is a scientific research task. And according to Cardellini (2006), it is more than placing numbers into the well-known formulas (Cited by Temel, 2013).

Ability to establish cause and effect relationship is both facility and necessity in learning and teaching sciences in the field of sciences as well, just like in all other fields. The fact that individuals become skillful at solving problems by establishing cause and effect relationship helps them produce suitable solutions for the daily life problems. However, since the students cannot adopt a systematic problem solving approach in the daily life, it is seen that they unfortunately get confused before even the smallest daily life problems. For this reason, importance of problem solving is emphasized on all occasions as a method in teaching and learning (Mei-Hung, 1993; St Clair-Thompson, Overton and Bugler, 2012; Temel and Morgil, 2012; Cai, 2003; Garderen and Montague, 2003; Jitendra, Griffin, Buchman and Sczesniak,2007; Karataş and Güven, 2004; Stoyanova, 2005).

Science uses the necessary researches to solve a problem (Ramig, Bailer, and Ramsey, 1995). Problem solving having place among the learning and renewal abilities, two of the 21st century abilities, means being able to think within the framework of a certain situation, decide what to do and how to do, use the existing opportunities and achieve the solution by this way (Trilling and Fadel, 2009). According to Burns et al. (1985) and Harlen (1999), the scientific operation abilities are such abilities that facilitate learning in sciences, bring in research ways and methods, are indispensable elements of scientific research or problem solving (Cited by Temiz, 2001).

In fact, the problem solving ability is a dynamic process shaped according to the type, nature and structure of the problem encountered. For this reason, the problem solving ability may vary since it is shaped according to the problems encountered by the individuals. One of the fields where such changes are frequently encountered and practical applications are required is chemistry. Through problem solving especially in the chemistry courses, individuals are required to solve difference types of problems both in traditional and innovative ways, and to reveal different points of views. Meeting these expectations becomes possible by bringing up individuals having developed problem solving abilities. Middlecamp and Kean (1987) argue that it is necessary to teach the students how to think in a way to determine the type of problems and select the strategy in accordance with the determined problem type.

Solution of the chemistry problems is a complex process, and proper execution of this process depends on the correct understanding of the concepts in a problem, correct determination of those given and required in a problem and the mathematical operation ability (Bilgin, 2015). On the other hand, solving problems by using the correct and short way has a very important place in succeeding in the chemistry courses. When the studies on problem solving in chemistry education are examined, it is seen that the studies, in which the algorithmic and conceptual problems are mentioned, come to the forefront (Coştu, 2007; Gultepe, Celik and Kilic, 2013; Salta and Tzougraki, 2011). Because it is possible to categorize the problems encountered in the chemistry courses in two general groups including algorithm and concept based ones (Kean, Middlecamp and Scott, 1988; Leonard, Gerace & Dufresne, 1999; Taconis, Ferguson-Hessler and Broekkamp, 2001). It is known that in particular, the way and approaches followed in the solution of algorithmic problems affect solution of the problem and in a correct way and short time. Algorithm is defined as a series of the operation steps to achieve the purpose of the problem (Middlecamp and Kean, 1987). The use of the conversion factor in solving the chemical problems is an algorithmic approach used widely among the chemists (Bodner, 1987).

One of these ways agreed to give both effective and more reliable results in solving the chemistry problems as well is the use of conversion factor. The conversion factor is an application based on the principal in which the same units in the numerator and denominator offset each other. In other words, the ratio of any two the numerical values given in a system to each other, together with their units, are called conversion factor. Both correct results and correct units are achieved through the conversion factors used to solve the chemistry problems. Generally, some calculations in chemistry require converting a quantity measured in a unit into another group of units. For example; considering the fact that 1 m = 100 cm, if we divide both sides of the equilibrium into 1m (1~~m~~/1~~m~~ =100cm/1m), the numerator and denominator on the left side of the equilibrium is identical and offset each other. The ones on the rights are not identical, but equal (1=100cm/1m). Because both of them represent the same lengths. When the ratio (100cm/1m) is multiplied with a length given in meter, it turns into a length with a cm unit. Here, this ratio explained with a simple example is called conversion factor. The calculations depending on the conversion factor have to comply with the following formula all the time.

wanted information = given information x conversion factor(s)

Generally, it is necessary to conduct several successive conversions to achieve the wanted result. Using the conversion factor, it should not be overlooked how the conversion factor is written, that the conversion factor may be reversed, a series of conversion factors may be used to create a conversion path, when necessary, the conversion factor may be squared, cubed (Petrucci, Harwood and Herrıng, 2010).

In chemistry education, many students memorize the equations and formulas, solve such problems requiring mathematical operations without understanding the subjects and concepts, however, they cannot answer the conceptual questions. For this reason, students become successful in the multiple choice examinations; however, they do not exactly know the chemical concepts related to the question (Nakhleh, 1993; Nakhleh and Mitchell, 1993; Nurrenbern and Pickering, 1987; Pickering, 1990, Nakiboğlu and Kalın, 2003) Most of the students identify the chemistry problems as hard (Nakiboğlu and Kalın 2003). The reason of this results from the fact that the students cannot learn the concepts correctly. In fact, the students learn the logic of the concepts through the conversion factor which they create together with the units. For example; the students cannot fictionalize the correct conversion factor without knowing that the quantity of substance dissolving in a liter of solution is called concentration. For this reason, knowing the concepts correctly is important along with the mathematical operations, as it is specified in many studies (Beall and Prescott1994, Nakhleh, 1992; Morgil et al. 2002; Frazer and Sleet 1984 and Ashmore et al.1979).

In science education, many concepts, constants and symbols are taught. However, it is not sufficient to know only concepts, it is important to recognize the constants existing in the formulas related to these concepts and to know the formula unit. In addition, this enables to achieve the formulas based on the units and to comprehend

the subject better without any need for memorization. However, most of the symbols and units are ignored and are not used by the students. The operations conducted without using the units and symbols but just memorizing the formulas are the temporary solutions that just save the day and bring in short-term success.

In sciences, since establishing a cause and effect relationship is one of the most basic ways of ensuring persistency in learning, the way and logic of reaching formulas should be comprehended by using the constants and units while conducting concept education. Both correct results and correct units are achieved through the conversion factors used to solve the chemistry problems. While the students achieve results by using miscellaneous formulas or conducting more than one mathematical operation, they can achieve correct results and correct units based on the unit removal principle in line with a certain order with the conversion factor method (Anılan, 2014).

Since the solution of chemical problems is a complex process, the process must primarily be carried out well. If depends first on correct determination of ones, which is given and required in the problem, and then on the mathematical process ability. It is assumed that the conversion factor, which is a method that can be used in solving the chemical problems, has any superior aspects compared to the ratio, proportion or some other methods. Therefore, in our study, it is important to see the approach of the teacher candidates before and after they learn to use the conversion factor. Because of use of the conversion factor, the students do not have to memorize the formulae to solve the problems. Furthermore, they do not have to memorize any units other than the units given in question and simple unit conversions. By using the conversion factor method, they finally obtain the unit together with the numerical value of the result they have calculated. Therefore, this study that we conducted for the teacher candidates is important, because the use of the conversion factor facilitates the solution of chemical problems. The fact that the teacher candidates approach problem solving processes through a different point of view is thought to contribute to the problem solving abilities of their students during their future professional lives. The object of this study is to determine the effect of use of the conversion factor, which the first class students of primary education science teaching department have experienced for the first time, on their success in problem solving, and the views of such students on the conversion factors.

Method

Research Model

In this study, we have used the mixed design. The mixed design model is one of the basic ways used to strengthen a research design. The mixed design model is identified as using both the quantitative and qualitative research methods together in a certain phase of any researches or during two or more phases of any research processes (Johnson and Christensen, 2008). The circumstances, when the researcher may receive the views of the participants on the experiment for the purpose of determining whether or not the results are consistent after conducting a quantitative study or experiment, may be given as an example of the mixed design method.

In the research, the pretest-posttest design without control group, one of the experimental designs, has been used. In this design, the effect of the experimental operation is tested through studies conducted on a single group. The measurements of the subjects related to the dependent variables are achieved by pretest before application and by posttest after the application by using the same subjects and measurement tools. (Büyüköztürk et al., 2012). The application of this study has been carried out with an experiment group without control group in the compulsory general chemistry course maintained in the primary education science teaching department of a state university. Since the application has been carried out within the scope of a single course, the whole group participated in the application compulsorily and a control group has not been selected. After the posttest, the views of the students have been collected with the qualitative data collection tools, and descriptive analysis has been used for analysis. The descriptive analysis is an approach that enables to explain, interpret the obtained data under the themes created, to examine the cause and effect relationship and to achieve the result (Yıldırım and Şimşek, 2013).

Study Group

The participants of the study are composed of 27 students studying in the first class of primary education science teaching program of a state university in the spring term of 2014-2015 academic year. The study was planned as 35 students. However, 8 students were not evaluated because they did not participate in the study regularly

Collection of Data

The data of the study has been collected in the following manner in compliance with two models. First of all, the quantitative data planned according to the pretest-posttest design without control group within the framework of the experimental design. In this context, the students have been given open ended questions for the pretest within the scope of the study conducted based on the pretest-posttest design without control group and they have been asked to solve these questions using the methods they know. The open ended questions prepared as pretest-posttest to obtain the quantitative data have been composed of seven chemistry problems that can be solved both through proportion and formula and conversion factor. Preparing the questions, we have paid attention that they are of simple chemistry subjects like density, unit conversion and solutions, which the students can solve using their pre-university (high school) knowledge. The said questions have been prepared taking the affirmative opinions of five experts of the field as a result of a wide field scanning, and they have been applied as pilot to 33 students studying in the first classes of primary education science teaching department another state university having similar properties. The questions prepared in this manner have been applied to the students as pretest. The subject on the conversion factors was described by the researchers to the same students theoretically and practically in eight course houses totally within a period of four weeks. Firstly, during the first two hours of this eight-hour course, any information about the measurable properties of the matter, significant figures, SI units of measurement was given and any explanations were made. In the following two hours, any explanations on definition and use of the conversion factor were made by giving examples. In the remaining four hours, the problems related to the conversion factor were solved together with the teacher candidates. The post-test application was not implemented immediately to observe the permanence of the results. The pretest questions applied at the beginning of the term to determine circumstances of the primary education science teaching students in problem solving with the conversion factor have been this time applied as posttest at the end of the term to determine circumstances of the students in problem solving with the conversion factor. Following the quantitative data collection phase comprising the pretest-posttest applications, the opinions of the students on the use of the conversion factor in solving the algorithmic problems after the posttest have been obtained in written through a questionnaire consisting of open ended questions in order to collect the qualitative data of the research. The open ended questions prepared have been applied after obtaining the affirmative opinions of the field experts.

The pre-test and post-test questions applied to teacher candidates:

1. The mass of a wood log is 2.52 kg. What is the density of the wood per cubic centimeter? The log is shaped like a rectangle prism. The dimensions are 1.08m, 5.1cm and 6.2cm.
2. To measure the density of trichloroethylene, a balloon was weighed out while it is blank and weighed as 108.6 grams, and after it is filled with 125mL trichloroethylene, total mass is 291.4 grams. What is the density of trichloroethylene in g/mL?
3. What is the mass in kilograms of 275mL ethanol sample at 20°C? (The density of ethanol at 20°C is 0.789g/mL.
4. What is the volume in liter of 50Kg ethanol at 20°C?
5. If the water density is 0.998g/mL at 20°C, please calculate its density in lb/ft3.

11b = 453.6g; 12 inches = 1ft; 1 inch = 2.54cm

6. A little seawater containing 3.5% NaCl by mass will be evaporated until it will be dried and 75g NaCl sample will be obtained. To that end, how much liter of sea water should be taken? (Density of sea water: 1.03g/mL)
7. Ethanol is 95.5% by mass. The density of the ethanol solution at 20°C is 0.802g/mL. What is the volume of ethanol solution to be used in an experiment that requires 125g ethanol?

Analysis of Data

Both the qualitative and the quantitative data have been obtained, since the mixed design method has been used in the research. For this reason, both the qualitative and the quantitative data analysis have been used in analyzing the data. In this context, first of all, the analysis has been conducted on the open ended questions, which constitute the quantitative dimension of the research and are applied according to the pretest-posttest experimental design model without control group. In this study, firstly, the open ended forms collected from the students have been enumerated, and then both solutions of the students have been separately assessed by both of two researchers. The answers of the students have been graded by the researchers as false (0 point), partially true (1 point) and fully true (2 points). Accordingly, the maximum grade that a student may obtain in this test is 14. The grades of both of the researchers have been compared for the grading reliability of the research, and the consistency has been seen to be 100%. In addition, 12 pretest-posttest solutions of the participating students,

which have been selected randomly, have been graded by a third field expert other than those two experts, and the grading reliability has been determined to be 100%. The data have been transferred to SPSS 13 program in order to determine whether or not there is any difference between the pretest and posttest points achieved in this manner, and the t test has been applied in order to determine whether or not there is significant difference in problem solving circumstances before and after applying the conversion factor.

After the posttest, the opinions of the students have been obtained for the qualitative data of the study. In this context, the opinions of the students on the use of the conversion factor in solving the algorithmic problems have been obtained in written through a questionnaire form consisting of open ended questions, and descriptive analysis has been used for analysis. The opinions of the students that they have submitted in relation to the use of the conversion factor have been separately read by both of the two researches. The opinions of the students have been categorized according to the common descriptions, and the categories have been determined by coding the obtained descriptions. The researchers have created encodes and categories independently from each other, later on, they have compared them for consistency. The subjects constituting "consensus" and "divergence" between the researchers have been determined. The encoder reliability has been found as 89% through the formula Consensus / (Divergence + Consensus) x 100 formed by Miles and Huberman (1994), and the determined categories have been concluded to be consistent. In addition, 10 written opinions of the participating students, which have been selected randomly, have been read by a third field expert other than those two experts, and the coded encodes have been seen to be consistent with those of the researches. The transparentness and understandability principals have been considered in presentation of the quantitative data, and the opinions of the participants have been directly cited in order to ensure understandability. Also, after the opinions of the students have been encoded by the researchers, five students selected randomly have been interviewed face to face and the students have been ensured to confirm their opinions. Later on, the findings obtained from the t test, which has been applied in order to determine whether or not there is significant difference in problem solving circumstances before and after applying the conversion factor, have been associated with the students' opinions on the conversion factors, and assessed and interpreted by giving place to the direct citations from the students' opinions. The names of the participating students have been kept confidential; the codes such as S1, S2 have been used in replacement thereof.

Results

Within the scope of the study conducted based on the pretest-posttest design without control group, in the first phase of assessment of the results of the study, the students have been given the open ended pretest-aimed questions composed of seven chemistry problems that can be solved both through proportion and formula and conversion factor. The students have solved the given problems using the methods they know. Later on, the subject on the conversion factors making up of the experimental dimension of the research has been lectured to the same students by the researchers in theory and application in eight course hours within a period of four weeks, and in the remaining period of the term, the students have been required to use the conversion factors while solving problems.

The teacher candidates have been applied t test in order to determine whether or not there is any difference between their chemistry problems solving circumstances before and after performing the theoretical and applied problem solutions related to the conversion factor method. The results have been presented in Table 1.

Table 1. Pretest-posttest t test results

Point	Groups	n		ss	sh	sd	t	p
Problem solving way	pretest	27	4.96	3.52	0.67	26	-5,881	.000
	posttest	27	9.63	3.43	0.66			

P<0.05

When pretest and posttest t test results are examined, it is seen that the pretest average is 4.96, while the posttest average is 9.63. It is seen that the difference between the pretest and the posttest is significant at the level of $p<0.05$ as a result of the statistical calculations performed. When the general opinions of the teacher candidates on the conversion factor method are assessed, although they have stated that this method is hard for them and they have difficulties, the pretest and posttest t test results have revealed that there is affirmative and significant

difference between successes of chemistry problems solving through the conversion factor method. The pretest and posttest t test results related to the chemistry problems have been presented in Table 2.

Table 2. The pretest and posttest results of the students included in the study group

	Pretest Results							Total Point		Posttest Results							Total Point
problem student	1	2	3	4	5	6	7	14		1	2	3	4	5	6	7	14
S1	0	2	2	2	0	2	0	8	S1	2	2	2	2	1	2	2	13
S2	2	2	2	2	0	2	2	12	S2	1	2	2	2	1	0	0	8
S3	2	0	2	2	0	0	0	6	S3	2	2	2	2	1	2	2	13
S4	1	2	2	0	0	0	0	5	S4	1	2	2	2	0	0	0	7
S5	1	2	1	1	0	1	1	7	S5	1	2	2	2	0	2	2	11
S6	1	2	0	1	0	1	1	6	S6	1	2	2	2	1	2	1	11
S7	1	0	0	0	0	0	0	1	S7	2	2	0	2	0	2	2	10
S8	1	2	2	2	0	0	0	7	S8	1	2	2	2	2	2	2	13
S9	1	2	2	1	1	0	0	7	S9	2	2	1	2	2	2	2	13
S10	1	2	2	1	0	0	0	6	S10	2	2	2	1	0	2	1	10
S11	1	2	2	0	0	0	0	5	S11	2	2	2	2	1	2	2	13
S12	0	0	2	0	0	0	0	2	S12	2	2	0	2	1	0	2	9
S13	2	2	2	1	0	1	0	8	S13	2	2	2	1	2	2	2	13
S14	0	0	0	1	0	0	0	1	S14	2	2	2	2	0	2	2	12
S15	1	1	1	0	0	0	0	3	S15	2	2	0	2	0	0	2	8
S16	1	2	2	1	0	1	0	7	S16	1	2	2	2	2	2	0	11
S17	2	2	2	2	0	0	0	8	S17	2	2	2	2	2	2	2	14
S18	1	2	2	1	0	0	0	6	S18	1	2	0	0	0	0	0	3
S19	1	2	2	1	0	0	0	6	S19	1	2	0	2	0	2	0	7
S20	0	0	0	0	0	0	0	0	S20	1	2	0	0	0	0	0	3
S21	1	0	2	0	0	0	0	3	S21	0	0	2	2	0	0	0	4
S22	2	2	2	1	1	1	2	11	S22	2	2	2	2	2	1	2	13
S23	2	2	2	2	0	0	0	8	S23	2	2	0	2	0	0	0	6
S24	0	0	0	0	0	0	0	0	S24	2	2	2	2	1	2	1	12
S25	0	0	0	0	0	0	0	0	S25	2	0	2	2	1	0	0	7
S26	0	0	0	0	0	0	0	0	S26	1	2	2	2	2	2	2	13
S27	0	0	0	0	0	0	0	0	S27	1	2	0	1	0	1	0	5

Generally, when the pretest-posttest results are examined, it is observed that there is increase on the points of 24 students out of 27 students after application of the conversion factor method. While the teacher candidates are seen to have received 0 point at the lowest and 12 points at the highest in the pretest, they are seen to have received 3 points at the lowest and 14 points at the highest in the posttest. The open ended chemistry questions asked to the students have been prepared taking into account the simple-to-complex principal. For this reason, the teacher candidates participating in the research are seen to have replied the first three questions both in the pretest and posttest correctly.

When the results of S17 who has received the highest point in the posttest, it is seen that he/she has replied the first three questions both in the pretest and posttest correctly, replied the other four questions in the pretest wrongly. In other words, it is seen that the teacher candidate replied the other four questions in the pretest wrongly through the methods he/she knows when the problems become more complex. As a result, the teacher candidate has received 8 points from the pretest, while he/she has received 14 points from the posttest. Generally, when the solutions of the teacher candidates are examined, while they perform false solution in the classical solutions as the data in the questions increase, since the conversion factor method requires writing the units respectively, it facilitates solution of the problem and leads to the correct solution.

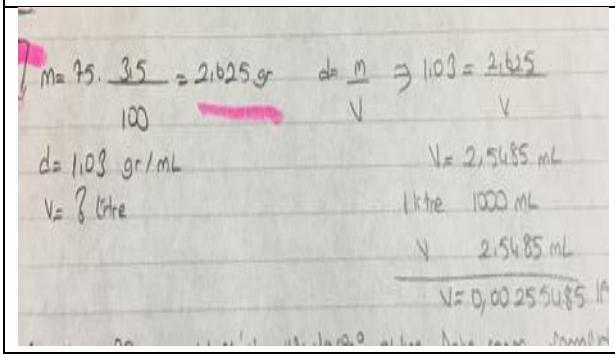
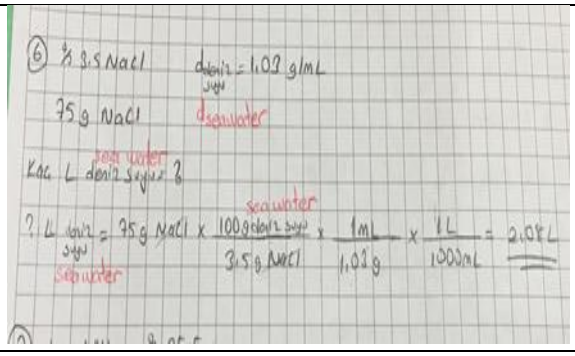
Pretest Solution	Posttest Solution
	

Figure 1. The pretest and posttest solutions of S3 teacher candidate

When the statements of the teacher candidates are examined, generally, they are seen to have found the last three questions a little complex. For example; as it is seen in Figure 1, S3, one of the teacher candidates, has solved the 6th question correctly in the posttest, which he/she has solved falsely.

> *"I had difficulties with the conversion factor at the beginning, however, later on, I get used to it. But I still have some troubles on what and where to write. But I think that it is a quite beautifully solution way. Because you conduct all operations in a single phase and solve the problem. And generally, I do not have any other troubles." (S3)*

In his/her statement, S3 specified that although she had difficulties while using the conversion factor method, it is a beautiful solution way. While the same teacher candidate has received a total of 6 points in the pretest, he/she has increased his/her point receiving 13 points in the posttest. Although he/she has found the conversion factor difficult, he/she has received 13 out of 14 points and become successful in solving the problems by using the conversion factor method.

When the pretest-posttest results are examined, it is seen that the teacher candidates S2, S18 and S23 have answered some questions in the pretest correctly, however; they have answered the same questions falsely in the posttest. As it is seen in Table 1, while S2 has received 12 points leaving one question blank, he/she has tried to solve all questions but received 8 points. According to this result, it is seen that although his/her point decreased in the pretest, he/she couldn't express an opinion, while he/she has tried to find a solution, although incorrect, and solve the question.

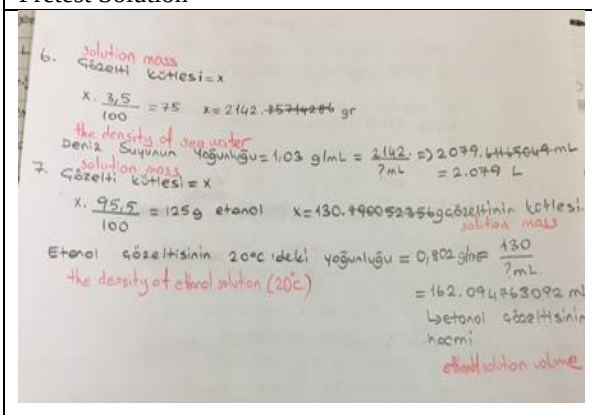
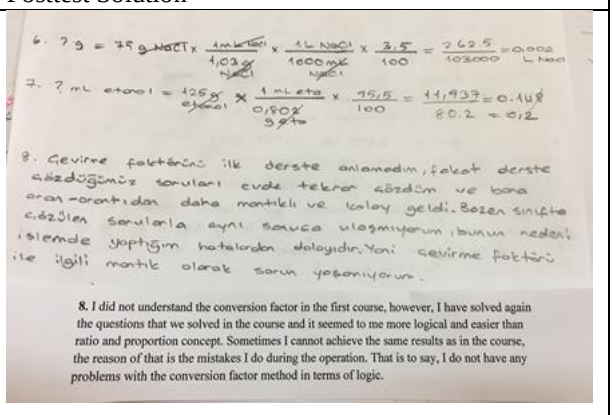
Pretest Solution	Posttest Solution
	

Figure 2. The pretest and posttest solutions of S2 teacher candidate

In Figure 2, it is seen that S2 has correctly answered another question in the pretest through traditional methods, has not exactly comprehended the conversion factor method in the posttest, and has falsely solved the question:

> *"I did not understand the conversion factor in the first course, however, I have solved again the questions that we solved in the course and it seemed to me more logical and easier than ratio and proportion concept. Sometimes I cannot achieve the same results as in the course, the reason of that is the mistakes I do during the operation. That is to say, I do not have any problems with the conversion factor method in terms of logic." (S2)*

Although his/her posttest point is lower, S2 states that he/she finds the conversion factor method more logical and easier than the classical solution methods. The fact that the teacher candidate does not approach to at least a new method with bias indicates that he/she shall use the conversion factor method in solving the chemistry problems as much as he/she uses and applies it.

It is also seen that some of the teacher candidates have left some questions blank in the pretest. Some of the statements of the teacher candidates as to why they have left blank or why they could not solve them are as follows:

> *"I have never performed the conversions in a correct way. I know mL=cm^3 but I cannot convert it." (S23)*
>
> *"I have difficulties to think about and interpret the questions, even not to mention that I cannot perform operations" (S24)*
>
> *"I have tried to solve the problems but I have never solved questions with operations during my high school education. I studied chemistry in the first year of high school and I did not have another chemistry teacher later on. I cannot solve such questions."(S26)*
>
> *"I have difficulties to perceive the questions. I have difficulties to perceive what the questions require probably from the fact that my chemistry knowledge is insufficient. I cannot see and start what I have to see and start at the first sight." (S27)*

Based on the statements of the teacher candidates S23, S24, S26 and S27, it is seen that for the reason why they have left the questions blank, they have stated that they did not understand them or their chemistry knowledge is insufficient. However, the contents of the questions are included even in the unit achievements of Science and Technology Course of secondary school prior to high school. Especially, the first three questions are at such level, which can be solved based on the units and formulas given in the secondary school science courses.

While the teacher candidates state that although they generally have difficulties in solving problems with the conversion factor method, they have started to get used to it by time, one teacher candidate said that "*I forget more quickly and have more difficulties in the conversion factor method than the ratio and proportion concept. I think that this method should not be used. (S23)".* The same teacher candidate has taken 8 point in the pretest, while 6 points in the posttest. When his/her statement as to why he/she has left the questions blank in the pretest is examined, he/she says that he/she has, in fact, deficiencies in the general information on the units.

Although some of the teacher candidates generally state that they cannot solve the problems due to the deficiency of chemistry knowledge, S20 stated that his trouble with the first question resulted from his mathematics knowledge: *"I cannot solve this problem. Because I do not know where to use the edges of rectangle." (S20)*

It is inevitable to use the mathematical operations in solving the chemistry problems. During problem solving, the students should bring together the concepts and the operations, and use them to solve the problem. In the operational problem solving, the solution methods used by the students comprises their existing knowledge as well as their mathematical knowledge and abilities. Since the problem solving is mostly composed of the mathematical applications and formulas, it is qualitative, and in this respect, it is the source great difficulties for most students. In the second phase of assessment of the results of the study, the opinions of the teacher candidates on the conversion factor have been categorized under themes and assessed.

Table 3. Opinion themes of the teacher candidate on the use of conversion factor

Theme	Code	Student
Difficulty	Complex questions	S5, S15, S17, S20, S24, S25, S26
	Determining the solution way	S6, S9, S18, S20, S21, S24, S27
	Determining the phases of the conversion factor	S3, S5, S16, S17, S23, S26
	Converting the units between each other	S4, S8, S9, S10, S14, S26
Simplicity	Short	S7
	Simple and practical	S1
	Logical	S2, S19, S27
	Low possibility of making mistakes	S11
	Saving on time	S13
	Simplicity in converting units	S12
	Simplicity in some questions	S17, S24
Difference	Entertaining and good	S3,S20

Different	S18
Convenient	S22

As it is seen in Table 3, the opinion themes of the teacher candidate on the use of conversion factor have been categorized under three main themes including difficulty, simplicity and difference. The difficulty theme is composed of 4 subthemes, the simplicity theme is of 7 and the difference theme is of 3 subthemes.

Difficulty

The statements of the teacher candidates under the difficulty theme have been categorized in 4 subthemes including "complex questions", "determining the solution way", "determining the phases of the conversion factor" and "converting the units between each other". When the pretest-posttest results are generally examined, it is observed that 24 out of 27 students have increased their points following application of the conversion factor method. The fact that a clear majority of the teacher candidates identify the conversion factor method as difficult although their success in problem solving by using the conversion factor method generally increases cause us to think that this difficulty includes other reasons. Although the use of the conversion factor method is a new method for the students in problem solving, the reason of the difficulty for the students results from the fact that they do not sufficiently command the issues such as units, unit conversion, mathematical operations, which are important for the conversion factor method and they had to have learned during their education life. When the statements of the teacher candidates in the subthemes are examined, each of the teacher candidates has mentioned about such difficulties.

Solving the Complex Questions

Under the subtheme of "solving the complex questions" specified within the "difficulty" theme, S5 and S25 have stated that they can solve the simple questions but have difficulties in the complex questions. It is seen that S20 is afraid of the complex questions and approach them with prejudice.

When the pretest and posttest points of the teacher candidates are examined, although they identify the conversion factor method as difficult, they are seen to be more successful in problem solving with the conversion factor method.

> *"I cannot still use the conversion factor method. I use it with the simple questions, but I cannot solve the difficult questions. I cannot correctly equalize the units. In fact, if I knew how to use it, it would be easier to solve the questions in a single step, but I cannot use it. I can solve these questions by using the ratio and proportion concept" (S5)*
>
> *"I cannot perform rounding-off. Also, when units are given like in the 5^{th} question, I am confused and cannot solve it. When the mass percentages are given like in the 6^{th} question, I cannot solve it. It is complex and cannot find a solution." (S15)*
>
> *"The conversion factor method is more entertaining for me. When the solution way is known, it gives more reliable results. However, starting to solve the question is the most important problem. While I pass from a certain proportion to another proportion in the conversion factor method, I cannot find the unit there. Just like in the 5^{th} question. Also, I forget the percentage questions by time. As seeing % makes me fear, I approach the question with prejudice. Just like in the 6^{th} and 7^{th} questions." (S20).*
>
> *"I have difficulties with the conversion factors including percentages." (S25).*

Inability to Know Where to Start Solving

The teacher candidates (S6, S9 and S18) have stated that they do not know where to start solving when they use the conversion factor method. The statements of the teacher candidates have been specified below.

> *"When I do operations, sometimes I cannot understand which one is primary. Sometimes when I use the calculator doing operations, the results are different from the correct values. When there is more than one value in the question, I do not know which one to start with. Here, I have also done operations using a calculator, however my results may be wrong. Because when making calculations from the telephone, it is written 7.500 instead of 7500 with thousands, therefore the result may be wrong on the phone." (S6)*
>
> *"I have difficulties when writing the units, I cannot be sure with which one to start. I write them in a complex manner and I have difficulties also in rounding off, I cannot round off." (S9).*

"Since we used the ratio-proportion concept during the high school, this method has seemed different. My problem with the conversion factor method is that I cannot find which one to start with. There are sometimes complex and long questions. Using the conversion factor method is more comfortable." (S18).

It can be concluded from the statements of the teacher candidates that they do not know how to use calculators and most importantly, the teacher candidates have difficulties in problem solving as they cannot organize the information provided in the questions. It may be thought that as they have mostly applied a directly result-oriented and time-challenging problem solving method in the multiple choice examinations so far, they have difficulties in problem solving with the cause-and-effect-oriented conversion factor method.

Placing Units in Order

When the statements of the teacher candidates are examined, it is seen that they have difficulties in putting in order and placing the numerical values in compliance with the units making up of the basic step of the use of the conversion factor method. The main reason for this difficulty may result from the fact that the teacher candidates cannot organize the information provided in the question. The fact that the students do not pay much attention to, memorize or use the units during their education lives may be enlisted among the reasons of having difficulty in using the conversion factor method.

"I had difficulties with the conversion factor method at the beginning, but later on, I got used to it. But I have little problems about what and where to write. However, I think that it is a quite useful solution way. Because you do all the operations in one step and solve the questions. Generally, I do not have any other problems." (S3).

"I have little problems with using the conversion factor method. I have difficulties in putting in order and when there are different units. I think that I have already used to it. Also, I cannot calculate density with the conversion factor method, I directly benefit from the formula." (S16).

"I have difficulties in making shifts. For some questions, the conversion factor method seems to be simple. And for some questions, the ratio-proportion concept seems to be simple. I cannot determine to shift from which data to which data." (S17)

Converting Units

In his/her statement, the teacher candidate (S4) specifies that he/she has difficulties as he/she memorizes and forgets. "Memorizing instead of understanding" continuously comes to the front in the courses as a general problem of all the students. Some students achieve instantaneous success as they study by memorizing, however, when the same knowledge is required, they have problems in organizing and using the knowledge. The reason why the teacher candidates have difficulties may result from the fact that they have problems in organizing and using their past knowledge.

"I quickly forget the unit conversions as I memorize them. Therefore I have difficulties. This may result from the fact that I mostly memorize them instead of understanding. This has seemed a little bit complex as we have used to use the ratio-proportion concept so far."(S4)

"I think that I only have small problems. For example,1 kg=1.000 g. I have sometimes difficulties due to excitement, because I think that I understand its logic and use this method. It seems to me easier than the ratio-proportion concept."1 (S8)

"I have difficulty when I write the units, I cannot be sure with which one to start. I write them in a complex manner, have difficulty in rounding off and I cannot round off."(S9)

"I am hard put to remember the units in liter and ft, lb units. Besides, as I forget to write units near them, I make more mistakes." (S10)

"I cannot round off. Also, when units are given like in the 5^{th} question, I am confused and cannot solve it. When the mass percentages are given like in the 6^{th} question, I cannot solve it. It is complex and cannot find a solution." (S14)

In science education, it is not sufficient to know only concepts. The students learn many symbols, constants and accordingly, units along with the concepts. In the use of the conversion factor method, it is very important to know and convert the units with each other. However, most of the symbols and units are ignored and are not used by the students. For this reason, it is seen that the students have difficulties in converting the units with each other. In some application questions, the students are given the unit relations of some units in order to convert them, and they are expected to place only these units. However, it is seen that the students have

difficulty in writing and starting to solve, as they have difficulties in converting the units between each other. This is also a basic problem during the application.

Simplicity

When the statements of the teacher candidates under the simplicity theme are examined, the simplicity of the factor has been categorized under 7 subthemes. These subthemes can be enlisted as "short", "simple and practical", "logical", "low possibility of making mistakes", "saving on time", "simplicity in converting units" and "simplicity in some questions". When the subthemes are examined, the teacher candidates have stated that this method is shorter (S7), more logical (S2, S19, S27), simple and practical (S1), the possibility of making mistakes is lower (S11) and it saves on time (S13) as compared to the ratio-proportion concept. The teacher candidates have stated that some questions are simpler (S17, S24) than those of the ratio-proportion concept and they can perform the unit conversion method more comfortably (S12). Under the theme simplicity, it is seen that the teacher candidates have adopted converting units as they say "I wish I had learned it before" (S1).

Short

In his/her statement, S7 has stated that the conversion factor method is a shorter method as compared to the ratio-proportion concept. Using the ratio-proportion concept and formulas, the result is achieved through many phases, while the correct result and correct units are achieved in a single phase with the conversion factor method in a certain order and based on the unit swap principle. "I think that the conversion factor method is a shorter method as compared to the ratio-proportion concept. I have adopted the conversion factor method." (S7)

Simple and Practical

Since the conversion factor method can be applied in a single phase, the teacher candidate has stated that he/she has had no difficulty as it provides simplicity and practicality: *"I wish I has learned the conversion factor method before. It is simpler and more practical as compared to the ratio-proportion concept and I do not have much difficulty." (S1)*

Logical

Although the teacher candidates are confused in their statements, they have identified the use of the conversion factor method as logical and stated that this method is simpler.

> *"I did not understand the conversion factor method in the first course, however, I have solved again the questions that we solved in the course and it seemed to me more logical and easier than ratio and proportion. Sometimes I cannot achieve the same results as in the course, the reason of that is the mistakes I do during the operation. That is to say, I do not have any problems with the conversion factor method in terms of logic." (S2)*
>
> *"I do not know why I cannot understand this issue. When you explain it, I understand. But I cannot solve it myself. Maybe it results from the fact that it is a different subject other than the ratio-proportion concept. But the conversion factor method seems logical to me, the ratio-proportion concept seemed more complex. The conversion factor method is not so." (S19)*
>
> *"I do not know what and where to use. In fact, when I see the solution, it seems to me very logical and simple but I do not know where to exactly start and where to make shift." (S27)*

Low Possibility of Making Mistakes

In his/her statement, *S*11 has specified that he/she can solve the problem comfortably by using the unit conversion method and stated that he/she has achieved the result in a simpler way.

> *"I like the conversion factor method much more than the ratio-proportion concept. It has facilitated my work. The possibility of making mistakes gets lower. Also, as the units follow each other, I achieve the result making estimates even when I do not know the subject matter. I like the conversion factor method, perform it in the courses but I have received 50 in the examination. I do not understand why it has turned out so." (S11)*

Saving on Time

In his/her statement S13 has specified that he/she has achieved the result in a shorter time as less operations are performed and it is of a single phase.: *"At the beginning, the conversion factor method seemed to me a little difficult but I have got used to it as I solve questions. I think that this method should be used because it saves on time." (S13)*

Simplicity in Converting Units

"I think that I solve the questions more comfortably when I use the conversion factor method. Although I have difficulty in some questions, I understood the ratio-proportion concept more difficultly." (S12)

Simplicity in Some Questions

The teacher candidates, who have stated that they cannot achieve the solution due to lack of knowledge when the problem data and the conversion factor method phases are increased, have also specified that the conversion factor method ensure simplicity in some questions. In fact, if the teacher candidates have sufficient knowledge and ability on units and unit conversion, they are thought not to have troubles in establishing the conversion factor method.

> *"I have difficulty in making shifts. For some questions, the conversion factor method seems simple. And for some questions, the ratio-proportion concept seems simple. I cannot determine to shift from which data to which data." (S17)*
>
> *"Although I encountered it in the university for the first time, I am sure that the results are achieved more simply than the ratio-proportion concept. However, I can be confused when there are units not familiar to me like in the 5^{th} question and sometimes I do not know with which data to start." (S24)*

Difference

Under the difference theme, 3 subthemes have been established based on the statements of the teacher candidates including "entertaining and good", "different" and "convenient".

Entertaining and Good

> *"I had difficulties with the conversion factor at the beginning, however, later on, I get used to it. But I still have some troubles on what and where to write. But I think that it is a quite beautifully solution way. Because you conduct all operations in a single phase and solve the problem. And generally, I do not have any other troubles." (S3)*
>
> *"The conversion factor method is more entertaining for me. When the solution way is known, it gives more reliable results. However, starting to solve the question is the most important problem. While I pass from a certain proportion to another proportion in the conversion factor method, I cannot find the unit there. Just like in the 5^{th} question. Also, I forget the percentage questions by time. As seeing % makes me fear, I approach the question with prejudice. Just like in the 6^{th} and 7^{th} questions." (S20).*

Different

"Since we used the ratio-proportion during the high school, this method has seemed different. My problem with the conversion factor method is that I cannot find which one to start with. There are sometimes complex and long questions. Using the conversion factor method is more comfortable." (S18).

Convenient

The teacher candidates have stated that the use of the conversion factor method in problem solving is *entertaining and gives reliable results (S3, S20)* and it is a *convenient method (S22)*, it is *different and comfortable* as compared to the ratio-proportion concept (S18).

"My results are much higher sometimes. This makes me feel that I have made it wrong, maybe it is wrong. This causes me to panic and erase and do it again, so I lose time. It is very convenient but the result leads me to the wrong way." (S22)

Discussion and Conclusion

According to the data obtained from the findings in this study, it is seen that problem solving abilities of the first class students of primary education science teaching department have increased thanks to the conversion factor method, which they have experienced in solution of some chemistry questions for the first time. When it is considered that correct problem solving has an important place in succeeding in the chemistry courses, the solution methods used by the students in the operational problem solving in the chemistry lessons comprise the existing chemistry knowledge as well as mathematics knowledge and abilities. In this context, it can be said that the students perform the interdisciplinary applications in a successful manner while they use this method. Since the students have achieved results through the similar methods in problem solving so far, they have stated that learning a new method and using it habitually seemed difficult at the beginning, however their pretest and posttest averages indicate that they are more successful in problem solving with the conversion factor method. When the statements of the teacher candidates are examined, it is seen that they have difficulties in putting in order and placing the numerical values in compliance with the units making up of the basic step of the use of the conversion factor method. The main reason for this difficulty may result from the fact that the teacher candidates cannot organize the information provided in the question. The fact that the students do not pay much attention to, memorize or use the units during their education lives may be enlisted among the reasons of having difficulty in using the conversion factor method. The high values obtained in the post-test results mean that they begin to configure and organize the obtained information, but they are aware of this challenge. Generally, when the solutions of the teacher candidates are examined, while they perform false solution in the classical solutions as the data in the questions increase, since the conversion factor method requires writing the units respectively, it facilitates solution of the problem and leads to the correct solution.

When the solutions of the students achieved through the ratio-proportion concept and formulas as reexamined, it is seen that some of the students have memorized the formulas, they cannot create opinions, in short, they have achieved the solutions with a method based on memorizing. Generally, the students tend to memorize various algorithms and mathematical equations rather than learning the concepts (Beall and Prescott, 1994). It is important that the students achieve both the result and unit organizing the units and numbers on a single phase in line with a certain order in order to get away from the parrot fashion, and use the conversion factor method so that they create opinions on many subject matters and know why they write them in order to establish this order. It is seen that when the students solve the problems using the memorized algorithms, they cannot learn the chemistry concepts behind these algorithms (Nurrenbern and Pickering, 987; Sawrey, 1990; Tinger and Good, 1990; Niaz and Robinson, 1992; Boujaode and Barakat, 2000).

In this study, the opinions of the teacher candidates on the use of conversion factor have been categorized under three main themes including difficulty, simplicity and difference. The difficulty theme is composed of 4 subthemes including "complex questions", "determining the solution way", "determining the phases of the conversion factor" and "converting the units between each other"; the simplicity theme is composed of 7 subthemes including "short", "simple and practical", "logical", "low possibility of making mistakes", "saving on time", "simplicity in converting units" and "simplicity in some questions"; and the difference theme is composed of 3 subthemes including "entertaining and good", "different" and "convenient".

When the subthemes of the difficulty theme are examined, the fact that a clear majority of the teacher candidates identify the conversion factor method as difficult although their success in problem solving by using the conversion factor method generally increases cause us to think that this difficulty includes other reasons. Although the use of the conversion factor method is a new method for the students in problem solving, the reason of the difficulty for the students results from the fact that they do not sufficiently command the issues such as units, unit conversion, mathematical operations, which are important for the conversion factor method and they had to have learned during their education life.

Gilbert (1980) has specified that one of the problem solving mistakes of the students is that they do not pay attention to the units, which they use when they solve problems. In addition, he has stated that the students have troubles in organizing the data and writing the conversion factors in a correct order. In some studies, it is stated that the reason why the students are unsuccessful in problem solving is that they cannot organize the

information provided in questions and apply a complex strategy in questions that require more than one algorithm (Gilbert, 1980; BouJaoude, Barakat, 2000). These results are seen to coincide with the results achieved in this study.

When the subthemes of the simplicity theme are examined, the teacher candidates have stated that this method is shorter, more logical, simple and practical, the possibility of making mistakes is lower and it saves on time as compared to the ratio-proportion concept. The teacher candidates have stated that some questions are simpler than those of the ratio-proportion concept and they can perform the unit conversion method more comfortably. Under the theme simplicity, it has seen clearly emphasized that the teacher candidates have adopted converting units as they say "I wish I had learned it before" (S1). Under the difference theme, the teacher candidates have stated that the use of the conversion factor method in problem solving is entertaining and gives reliable results and it is a convenient method, it is different and comfortable as compared to the ratio-proportion concept.

In conclusion, it is seen that problem solving abilities of the students have increased thanks to the conversion factor method. And from the statements of the students, it is seen that the reasons for their having difficulty and failure are connected with applying a new method and insufficiency to organize the deficiencies and data in the basic science and mathematics infrastructures to be used by them during application. For this reason, it is important that the teachers have obtained different problem solving abilities, can use many different information and solution ways together without memorizing formulas by using the concept education, constants and units in order to ensure persistency in education establishing the cause-and-effect relation, and can organize the data and have an ability to solve the problems without memorizing. In the chemistry courses, the use of the conversion factor method can be said to have made positive contribution to the approach and attitudes of the students to the chemistry course. Similar studies indicate that the new methods contribute in increasing interest of the student in the chemistry course (Adigwe 1993; Hass and Parkay, 1993). No doubt that the most important role to eliminate the troubles of the students in solving the chemistry problems belongs to the teachers. Another object of this study is to determine the reasons of learning disability in a correct and realistic way. If a teacher knows what troubles the students have when they solve such problems, he/she may prevent students' failure by using the appropriate methods (Nakiboğlu and Kalın, 2003).

In addition, it is considered that using the conversion factor method in the chemistry courses will make positive contribution for the opinions of the students in problem solving (Tatar, 2015). When the importance of concept teaching and problem solving in chemistry is considered, it may be suggested to revise the programs in respect of content and context, and to carry out more studies on the complex relationships between the learning approaches of the students and problem solving in chemistry.

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