Pre-service science teacher practice of mathematics in operational physics and chemistry problems

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Abstract

The aims of this research are: to define Mathematics usage inclinations of pre-service science teachers in operational physics and chemistry problems and to evaluate them in terms of various socio-demographic varieties. The development study of Mathematics usage scale in Operational Physics and Chemistry Problems (MUSOPCP) constitutes the first stage of the research. For the second stage of the research, the scale which is developed by the researchers has been applied to 173 pre-service science teacher. SPSS 16.00 is used to analyze the data. The results give us the conclusion that the pre-services are conscious of Conceptual knowledge and Mathematics Knowledge Relation in Operational Physics and Chemistry but they have higher Mathematics anxiety than expected while solving operational Physics and Chemistry problems.

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1. Introduction

Science education uses problem solving as a method for teaching basic fields; physics, chemistry and biology.

Instruction in science is generally aimed at achieving two goals: the acquisition of a body of organized knowledge in a particular domain and the ability to solve problems in that domain. Much of the problem solving is quantitative, involving formulae and the application of mathematics, and is a source of great difficulty for many students.

Problem solving is one of the most important issues in science education research. Many studies have been conducted on the problem solving models (for example: Bennett, 2008; Bodner, 2003; Bodner & Domin, 2000; Johnstone & El-Banna, 1986 etc.), the types of problems (for example: Bennett, 2008; Johnstone, 2001; etc.), the opportunities for development of problem-solving skills (for example: Bodner, 2003; Cardellini, 2006; Cooper, Cox, Nammouz & Case, 2008; Johnstone, 2001; Johnstone & Otis, 2006; Wood, 2006; etc.), the cognitive variables of the
successful problem solving (Lee & Fensham, 1996, Lee, Goh, Chia. & Chin, 1996, Lee, Tang, Goh. & Chia, 2001) and so on.

Problem solving is an action has a wide range of mental processes and skills when reached the correct conclusion. An individual with advanced problem solving skills can effectively use knowledge and can easily solve the problems encountered (Altun, 2010).

The solution methods of students, used in operational problems in chemistry and physics lessons, cover both their existing chemistry, physics and mathematics knowledge and ability. A variety of mathematical operations while making calculations and effective use of formula is required especially to find data that should be calculated by using of complex formulas.

Science subjects, such as physics and chemistry, contain three levels of knowledge, namely, the macroscopic, the microscopic and the symbolic (Johnstone, 1991). The macroscopic level is a concrete level corresponding to observable objects, their properties and the terms used to describe them. The microscopic level involves the concepts, theories and principles needed to explain what is observed at the macroscopic level. The symbolic level deals with formulae and mathematical calculations. This may have significance in problem solving in chemistry and physics in that, if a problem requires confidence in moving between all three levels, then a source of difficulty has been introduced at the outset which hinders successful problem solving. It is hard for pupils to learn, if they have to learn these three aspects of knowledge simultaneously. Scientists and science teachers operate across all three levels of thought quite easily and switch from one mode of thinking to another without effort.

One of the most important reasons of students’ failures in physics and chemistry problem solving is calculation based problems. Students’ attitudes, self-efficacy and motivation are variables which play an important role in this type problem solving.

Mathematics anxiety is the state of tension preventing us from using the numbers and finding the solutions for Mathematics Problems in daily or academic life or it is the illogical state of terror lowering their performance in Mathematical Thinking, consequently impeding their learning (Miller and Mitchell, 1994). First recorded research on Mathematics anxiety is carried out by Dreger and Aitken (1957) and they defined it as the negative emotional reactions maintained against the field of Arithmetics and Mathematics. The negative attitude adopted against Mathematics can be seen as an important factor preventing the outcome of Mathematics ability in students. Students under the effect of such an anxiety are not able to receive the intended Mathematics education and use it, at the same time they are not able to practice a meaningful learning but a short term learning through memorizing without internalizing and comprehending the knowledge. Thus; the existence of knowledge in the memory diminishes due to the fact that a permanent learning is not implemented.

The aims of this research are: to define Mathematics usage inclinations of pre-service science teachers in operational physics and chemistry problems and to evaluate them in terms of various socio-demographic varieties. In this context the answers to the questions below has been researched:

- What are Mathematics usage inclinations of pre-services in operational physics and chemistry problems?
- How do the Mathematics usage inclinations of pre-services in operational physics and chemistry problems vary according to the gender, class and completed secondary education varieties?

2. Method

2.1. Research Model:

Research model is relational screening. In this relational screening model in order to reach certain aims, the relation between special events are tried to be explained and the existence or the level of covariance between two or more variances are tried to be determined (Cohen, Manion & Morrison, 2000; Karasar, 2008). The development study of Mathematics usage scale in Operational Physics and Mathematics Problems (MUSOPMP) which is applied as an evaluation tool is held as part of the research.
2.2. Population and Sample:

The population of this study is formed by the students taking “General Chemistry” and “General Physics” at Faculty of Education. Within these population 434 pre-service teachers chosen from various departments of Science Education, Classroom Teaching, Gifted Education constitutes the sample. 257 of pre-services (59.2%) are female and 176 of them (40.8%) are male; 78 of them (18.0%) are freshman, 141 of them (32.5%) are sophomore, 105 of them (24.2%) are junior and 110 of them (25.3%) are senior students. 173 of them (40.1%) are pre-service science teachers while 168 (35.5%) are pre-service classroom teachers and 106 (24.4%) are pre-service gifted education teachers.

2.3. Data Collection Instruments and Data Analysis:

The development study of Mathematics usage scale in Operational Physics and Chemistry Problems (MUSOPCP) constitutes the first stage of the research. MUSOPCP formed by 10 statements requiring “yes”, “no” and “neutral” as choice of answers is a three-point likert scale. As a result of the item analysis and discrimination process conducted, all 10 statements in the scale are proved to be reliable. Following the factor analysis, it is noticeable that the scale is in two factor structure and disclosed total variance is 46.864 %. These factors are defined as: 1. Mathematics anxiety in Operational Physics and Chemistry Problems 2. Conceptual knowledge and Mathematics knowledge relation in Operational Physics and Chemistry Problems. First factor consists of the statement numbers 2, 4, 5, 7, 9, 10; second factor consists of the statement numbers 1, 3, 6, 8. Item factor weights change between minimum 0.503 and maximum 0.781. Total cronbach of the scale is α=.713 and cronbach for the first factor “Mathematics Anxiety in Operational Physics and Chemistry Problems” is α=.720; cronbach for the second factor “Concept knowledge and mathematics knowledge connection in Operational Physics and Chemistry Problems” is α=.675. According to the result of Test- Retest, reliability coefficient for the total test is r=0.777, p<.01 and for “Mathematics Anxiety in Operational Physics and Chemistry Problems” it is found as r=0.777, p<.01, for “Concept knowledge and mathematics knowledge relation in Operational Physics and Chemistry Problems” it is found as r=0.673, p<.01. The minimum and the maximum score that can be taken from the scale is between 6-18 for the first factor, 4-12 for the second and 10-30 for the total score.

For the second stage of the research, the scale which is developed by the researchers has been applied to 173 pre-services science teacher taking “General Chemistry” and “General Physics” at Faculty of Education. One-way ANOVA, independent T-Test has been conducted to monitor the scores taken from the scale in terms of socio-demographic varieties. SPSS 16.00 is used to analyze the data.

3. Findings

In this part of the study collected data are handled and interpreted within the frame of sub-problems.

3.1. Sub-Problem 1: What is the pre-services’ Mathematics usage level in Operational Physics and Chemistry Problems?

In order for determining pre-services’ Mathematics usage level in Operational Physics and Chemistry Problems, MUSOPCP which is developed by the researchers and containing two factors, has been applied to 173 pre-services science teacher and the results has been shown in Table 1.

| Table 1. Distribution of average scores of pre-services taken from MUSOPCP according to the factors |
|--------------------------------------------------------------------------------------------------|
| N | 1st Factor Average Score | 2nd Factor Average Score |
|   | X | SS | SH | X | SS | SH |
|---|---|----|----|---|----|----|
| 173 | 9.3642 | 2.96693 | .22557 | 11.5723 | .98932 | .07522 |
As shown in Table 1, Pre-services’ average score for the first factor which is Mathematics Anxiety in Operational Physics and Chemistry Problems is found as 9.3642; and average score for the second factor which is Concept Knowledge and Mathematics Knowledge Relation in Operational Physics and Chemistry problems is found as 11.5723.

3.2. Sub-Problem 2: How do the Mathematics usage levels of pre-services in Operational Physics and Chemistry Problems vary according to the gender, class and completed secondary education varieties?

As shown in Table 1, Pre-services’ average score for the first factor which is Mathematics Anxiety in Operational Physics and Chemistry Problems is found as 9.3642; and average score for the second factor which is Concept Knowledge and Mathematics Knowledge Relation in Operational Physics and Chemistry problems is found as 11.5723.

Table 2. Independent group T–test results applied to define whether the scores taken from the MUSOPCP factors differentiate according to the gender variance

| Factors | Group | N   | X     | SS    | SH      | T–test | t   | Sd   | p     |
|---------|-------|-----|-------|-------|---------|--------|-----|------|-------|
| 1.      | Female| 122 | 9.4016| 3.00319| .27190  | .04688 | .256| 171  | .798  |
|         | Male  | 51  | 9.2745| 2.90571| .40688  |         |     |      |       |
| 2.      | Female| 122 | 11.7131| .72133| .06531  | 2.321  | 61.5| .024 |
|         | Male  | 51  | 11.2353| 1.39411| .19521  |         |     |      |       |

As in Table 2, as a result of independent group T–test applied to define whether the scores taken from the MUSOPCP’s first and second factors differentiate according to the gender variance; for the second factor scores the difference between the arithmetic average of the group has been found statistically significant but the difference is found out to be insignificant for the first factor. Female pre-services’ score average is significantly higher than the male pre-services.

Table 3. The result of one-way analysis of variance (ANOVA) applied to define whether the scores taken from the MUSOPCP factors differentiate according to the class variance

| Factors | Group       | N   | X      | SS    | Var. K. | K.T. | Sd   | K.O. | F    | p     |
|---------|-------------|-----|--------|-------|---------|------|------|------|------|-------|
| 1. Grade| Anatolian   | 74  | 9.0270 | 2.83797| Between | 23.766| 2    | 11.883| 1.356| .261  |
|         | Teacher     | 44  | 9.9545 | 2.86076| Within  | 1490.291| 170 | 8.766 |     |       |
|         | General     | 55  | 9.3455 | 3.19269| Total   | 1514.058| 172 |       |     |       |
|         | Total       | 173 | 9.3642 | 2.96693|         |       |     |      |     |       |
| 2. Grade| Anatolian   | 74  | 11.5270| 1.02333| Between | .378  | 2    | .189  |     |       |
|         | Teacher     | 44  | 11.5682| .89955 | Within  | 167.969| 170 | .988  |     |       |
|         | General     | 55  | 11.6364| 1.02494| Total   | 168.347| 172 |       |     |       |
|         | Total       | 173 | 11.5723| .98932 |         |       |     |      |     |       |

As in Table 3 as a result of one-way analysis of variance (ANOVA) applied to define whether the scores taken from the MUSOPCP factors differentiate according to the class variance; no significant difference has been encountered statistically between the arithmetic averages of classroom groups.

Table 4. The result of one-way analysis of variance (ANOVA) applied to define whether the scores taken from the MUSOPCP factors differentiate according to the completed secondary education variance

| Factors | Group       | N   | X      | SS    | Var. K. | K.T. | Sd   | K.O. | F    | p     |
|---------|-------------|-----|--------|-------|---------|------|------|------|------|-------|
| Anatolian| Teacher     | 44  | 11.5682| .89955 | Within  | 167.969| 170 | .988  |     |       |
|         | General     | 55  | 11.6364| 1.02494| Total   | 168.347| 172 |       |     |       |
|         | Total       | 173 | 11.5723| .98932 |         |       |     |      |     |       |
As a result of one-way analysis of variance (ANOVA) applied to define whether the scores taken from the MUSOPCP factors differentiate according to the completed secondary education variance; no significant difference has been encountered statistically for all the factors (Table 4).

4. Discussion and Conclusion

Mathematics Anxiety in Operational Physics and Chemistry Problems which is the first factor of pre-services’ Mathematics Usage Scale in Operational Physics and Chemistry has an average score of 9.3642 and standard deviation is 2.96693. This result is close to 6 which is the minimum score that can be taken. Concluding from this result it can be stated that, though under the average, teacher pre-services have a higher level of anxiety than expected. The second factor Conceptual knowledge and Mathematics Knowledge Relation in Operational Physics and Chemistry average score is 11.1109 and this result is very close to the 12 which is the maximum score that can be taken and furthermore, standard deviation, found as .98932, shows that the student scores are generally high. This result gives us the conclusion that the pre-services are conscious of Conceptual knowledge and Mathematics Knowledge Relation in Operational Physics and Chemistry but they have higher Mathematics anxiety than expected while solving operational Physics and Chemistry problems. According to the researches by İşleyen and Işık in 2003, the examinations conducted by OSYM obstruct mathematical thinking, Mathematics education and learning during the preparation of the students to a higher education foundation as memorization method is used instead of a logical approach to the problem. Yücel (2008) has stated in his study that the fear of failing in Chemistry results in anxiety. Czerniak and Chiarelott (1984) showed that higher level of science anxiety accompanies lower success in science and they also remarked science anxiety as a factor affecting success in science. Eddy (2000) pointed out that the students with less Chemistry anxiety are more successful in learning Chemistry. The factors, causing Chemistry learning anxiety among successful students are Mathematics usage, inability to answer the questions and inability to connect with the daily life. Research by Babayeva (2000) indicates a significant relation between student’s ability to solve algorithmic problems and learning Chemistry concepts. Researches can be found related to the necessity of operational problems and concept knowledge (Erdemir, 2009; Zhang & Watkins, 2001).

For the second factor of MUSOPCP which is Relating conceptual knowledge and mathematics knowledge in Operational Physics and Mathematical Problems, the level is significantly higher for the female students in comparison with the male students. No significant difference has been encountered for the second factor Mathematics Anxiety in Operational Physics and Mathematical Problems according to the gender variance. Graybill (1975) studied whether mental development and problem solving skills are in connection with the sex in his article “Sex Difference in Problem Solving Skills” and problem solving performance of males are found to be better compared to the females in the selected problems. Sezgin, Çalışkan, Çallica, Ellez & Kavcar. (2000) in their research conducted to find out problem solving strategies of university students having science lessons, indicated that there is no difference between the strategy preference of males and females and also between the students of Physics, Chemistry, Biology and Science Departments.

As for the sub-factors of MUSOPCP which are Mathematics Anxiety in Operational Physics and Mathematical Problems and Conceptual knowledge and Mathematics Knowledge Relation in Operational Physics and Chemistry, no significant difference has been pointed out according to the variance of class and completed secondary education types.

The suggestions below can be made in parallel with the results received from the research;

We can see that pre-services are conscious of the relation between the conceptual knowledge and mathematical knowledge in operational physics and chemistry problems however they experience Mathematics anxiety while solving the operational physics and chemistry problems. This anxiety probably results from the lack of Mathematics knowledge. In this context studies should be made in order to compensate the lack of knowledge and improve their ability to use Mathematics during the education of pre-services.

Increasing the examples given from daily life concerning usage of mathematics in Physics, Chemistry and Biology subjects will enable the integration of these information fields and this will be helpful to make connections between the science fields.
The condition of pre-services in different faculties and universities can be identified by applying to “Mathematics Usage Scale in Operational Physics and Chemistry Problems”.
This research and similar studies which is done quantitatively can be supported by qualitative studies and clinical interviews.

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