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The understanding levels of preservice teachers' of basic science concepts' measurement units and devices, their misconceptions and its causes

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Abstract

In this study it is aimed to determine preservice science teachers' and elementary teachers' level of understanding about measurement units, and devices; and misconceptions about basic science concepts (mass, weight, density, heat, temperature, energy, specific heat etc.). The sample included 92 undergraduate students who are second year preservice elementary teacher; and first and second year elementary science teacher. In this study the data was collected through data meaning-analysis table, which is one of the types of related diagram. In order determine the cause of the problems they encounter while learning measurement devices and units, 12 participants were interviewed using open-ended questions as well. It has been found that preservice teachers have misconceptions in the concepts and units about mass, weight, heat, temperature, energy and specific heat. Interview showed that more attention should be given to related courses which focus on measurement devices and units.

Keywords: unit of measurement, measurement devices, misconception, science concepts, preservice teachers

1. Introduction

Misconception is expressed as the significant difference between one's understanding of the concept and its universal use of scientific meaning of the information (Stepans, 1996; Gülçiçek, 2001). Nussbaum & Novice (1998) stated that misconception, which has a vital importance in science education, has inhibitory effects on making students learning new knowledge, so it makes teaching more difficult to a great extent. Teaching the concepts wrongly or making wrong interpretation may lead to misconception and this may direct students' wrong use of information or even student not being able to use that information at all. One of the important factors of this case is teachers. The most important factor deriving from teacher in misconception is teachers' attempt to teach more than one concept at a time and they try to teach the concept they do not know exactly (Lawson, 1995). Abstract concepts constitute a big part in science teaching. Therefore, students have difficulty in understanding these concepts. It is required that researchers should work towards the elimination of errors in the area that students have difficulty in understanding, their misunderstanding, or the ones they do not understand at all. From the beginning of the elementary education, in order to overcome these misconceptions, teacher candidates' incompetence should be eliminated at first. In this way, teachers may be more effective while resolving their students' misconceptions in the

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future. Thus, in this study it is aimed to determine preservice elementary teachers, and preservice elementary science teachers' understanding basic science concepts belonging to the measurement units (mass-weighted, density, heat, temperature, energy, specific heat) and devices, and their misconceptions about these topics.

2. Methodology

The sample included 92 (57 female; 35 male) undergraduate students who are second year preservice elementary teacher; and first and second year elementary science teacher. In determining the level of understanding of the concepts and misconceptions about the concept interview, concept mapping, word association, forecast-observation-explanation, and related diagrams are among the used methods. In this study the data was collected through data meaning-analysis table, which is one of the types of related diagram. Unit of measurement and devices related with basic science concepts are included in meaning-analysis table. Descriptive statistics were used to analyze the data. In order determine the cause of the problems they encounter while learning measurement devices and units, 12 participants (7 female, 5 male) were interviewed using open-ended questions as well.

2.1. Data Analysis

Descriptive statistics were used to analyze quantitative data. By analyzing students' answers to the questions in meaning-analysis table, the frequency and percentage of correct and incorrect answers are given in the table. In the analysis of qualitative data, each student's answers to questions were coded by the researcher and reflected as it is without making any changes.

3. Findings

In this section, findings from meaning-analysis table and responses to interview questions from the students are presented.

Table 1: The distribution of responses associated with the concept of a unit of weight and measurement tools

Concept	Right					Wrong					
	Measurement Unit		Measurement Devices			Measurement Unit					Measurement Devices
Weight	newton	dyn	dynamometer	weighbridge	bascule	kg	g	mg	kg/m^3	dyn/cm^3	balance
	46	2	36	49	49	36	26	15	5	3	34

As shown in Table 1, 46 of the students (50%) expressed the unit of weight as Newton truely, while 36 students (39%) expressed the unit of weight as kg, 26 (28%) as gram and 15 (16%) as mg improperly. 49 (5%) students stated that measurement devices of weight are weighbridge and balance, 36 (39%) as dynamometer; 34 (37%) has stated balance as weights' measuring devices unacceptably. It shows us that students have confusion about the concepts of mass and weight and their measuring devices.

Table 2: The distribution of student responses about the concept of mass, measurement units and measurement devices

Concept	Right				Wrong						
	Measurement Unit			Measurement Devices	Measurement Unit		Measurement Devices				
Mass	kg	g	mg	balance	newton	kg/m^3	weighbridge	bascule	dynamometer	pycnometerr	densimeter
	70	69	43	59	12	1	28	26	12	1	1

From the point of concept of mass evaluation, 70 of students (76%) affirmed kg as the unit of mass, 69 (75%) as gram and 43 (47%) as milligram truly while 12 (13%) stated the measurement unit of mass as Newton incorrectly. Besides, 59 students (64%) detected balance as a means of measuring scale of the mass correctly but 28 (30%) stated as weighbridge, 26 (28%) as bascule and 12 (13%) stated as a dynamometer incorrectly.

Table 3: The distribution of student responses about the concept of density, measurement units and measurement devices

Concept	**Right**				**Wrong**									
Density	Measurement Unit		Measurement Devices		Measurement Unit									Measurement Devices
	g/cm^3	kg/m^3	pycnometer	densimeter	kg	g	mg	dyn	dyn/cm^3	J/kg^0C	^0C	K	cal	dynamometer
	86	54	7	3	4	3	1	1	20	1	1	1	1	3

As it can be understood from Table 3, 86 of students (93%) expressed the concept of measurement units of density as g/cm^3, and 54 (59%) in the form of kg/m^3 correctly, while 20 (22%) stated it as dyn/cm^3 incorrectly. Only 7 (8%) of the students are aware of pycnometer and 3 (3%) of them are conscious about densimeter as measurement tools of density.

Table 4: The distribution of student responses about the concept of heat-related measures and measurement tools

Concept	**Right**			**Wrong**					
Heat	Measurement Unit		Measurement Devices	Measurement Unit					Measurement Devices
	J	cal	calorimeter	^0C	^0F	^0R	K	J/kg^0C	thermometer
	37	71	69	6	5	5	10	12	2

From the perspective of the concept of heat, 37 students (40%) relate joule and 71 (77%) cal measurement units with this concept right. However, 12 (13%) of them stated J/kg^oC and 10 (11%) stated Kelvin as heat units incorrectly. Besides, 69 students (75%) of the participant affirmed calorimeter as a heat measuring devices accurately.

Table 5: The distribution of student responses of the temperature measurement unit associated with the concept and measurement tools

Concept	**Right**					**Wrong**		
Temperature	Measurement Unit				Measurement Devices	Measurement Unit		Measurement Devices
	^0C	^0F	^0R	K	thermometer	cal	J/kg^0C	calorimeter
	86	64	54	57	87	1	2	2

As shown in Table 5, 86 of students (93%) ^{0}C, 64 (70%) of ^{0}F of, 57 (62%) K (kelvin) and 54 (59%) ^{0}R affirmed the measuring units of temperature as truly. Likewise, 87 (95%) of all students stated truly that thermometer measures the temperature.

Table 6: The distribution of student responses about energy measurement units and measurement devices

Concept	Right			Wrong												
	Measurement Unit		Measurement Devices	Measurement Unit								Measurement Devices				
Energy	J	cal	calorimeter	N	dyn	kg/m^3	Dyn/cm^3	^0F	^0R	K	J/kg^0C	dynamometer	bascule	densimeter	pycnometer	thermometer
	60	30	12	6	5	1	1	2	2	2	8	4	1	1	5	2

In Table 6, 60 of the students (65%) expressed J and 30 (33%) cal unit of measurement of energy were truely. But, 8 (9%) stated J/kg^oC and 6 (7%) N as units of measurement units of energy as they are wrongly stated. Only 12 (13%) of the students associated calorimeter as energy measuring devices.

Table 7: The distribution of student responses about specific heat measurement units and measurement tools

Concept	Right	Wrong															
	Measurement Unit	Measurement Unit							Measurement Devices								
Specific Heat	J/kg^0C	Kg	g	mg	g/cm^3	kg/m^3	dyn	dyn/cm^3	^0C	^0R	K	J	cal	dynamometer	pycnometer	densimeter	calorimeter
	44	2	2	1	5	3	5	5	3	1	5	6	19	1	10	13	7

As understood from Table 7, 44 (48%) of students truely associated J/kg^oC as the unit of measurement of the concept of specific heat. 19 (21%) cal, 13 (14%) densimeter and 10 (11%) pycnometer incorrectly stated as measurement tools belonging to the concept of specific heat.

To support quantitative data, the researcher interviewed with 12 preservice teachers (7 female; 5 male) in order to determine the cause of the problems they encounter while learning measurement units and devices topic. The student responses to the interview questions presented in Table 8.

Table 8: Students views about their causes of problems encountered during learning measurement devices and units

Question 1:	*The measuring unit concepts that students have difficulty while learning;* Heat, temperature, mass, weight, specific heat, density	***Causes*** • Concepts being measured by more than one unit of measurement • Not using these units in daily life • Not focusing on these subjects sufficiently during the courses
Question 2:	*The measuring devices concepts that students have difficulty while learning;* Heat, density, specific heat, energy	***Causes*** • Not using these units in daily life • Not focusing on these subjects sufficiently during the courses • Not being previously encountered with these devices.
Question 3:	*problems experienced while determining the measurement units which corresponds to other metric units;* During the interview, eight of the participants stated that they have difficulty in determining the measurement units which corresponds to other metric units. Two of them stated that they do not have any difficulty and 1 stated that he/she sometimes has difficulty and 1 left the question.	***Causes*** • Not knowing all measurement units are unknown • Using one single unit system in courses • Not focusing on measurement units sufficiently in courses.
Question 4:	*Can a concept be measured more than one measuring device?* All of the students stated that any concept can be measured by more than one unit of measure.	***Causes*** • While teaching Measurement units, measurement devices are not emphasized sufficiently • In courses, numerical data are emphasized rather than measurement devices
Question 5:	*Concepts which are used interchangeably in everyday life;*	• Just theoretical expressions of concepts

	Heat, temperature, weight, mass	• Semantic similarity between concepts • In daily life, these concepts are used interchangeably and incorrectly • In class, these concepts are not explained in detail.

4. Conclusions

According to the quantitative findings gathered from this study, it has been identified that preservice elementary teacher and elementary science teacher participated in the research have misconceptions about basic science concepts, (mass-weighted, density, heat, temperature, energy, specific heat), measurement units and devices. It has been found that they have difficulty in leaning such tasks as well. Likewise it can be interpreted that students have confusion regarding the definition of basic science concept such mass-weight; heat-temperature. Many of the findings from other studies also support the findings of this study (Carlton, 2000; Kesidou & Duit, 1993; Koray, Özdemir & Tatar, 2005; Ongun, 2006; Çepni, 1997). When the qualitative findings are examined, the qualitative findings supported quantitative findings in a way that; the students, in general, have trouble in understanding the measurement units of heat, temperature, mass, weight, specific heat and density; they also have confusion about the measurement devices of the concepts heat, density, specific heat and energy; they have difficulty in converting different measurement units to each other; and they use the terms heat and temperature interchangeably as well. As a consequence, it has been identified that the reason why the students have misconception about basic science concepts, measuring devices and measuring units is that; not using of these units and devices in daily life, the courses are not satisfactorily focus on these issues, the theoretical but not practical stress of these concepts during the courses, and semantic similarities between these concepts. When the obtained results from the study are evaluated, it has been suggested that laboratory classes should be concentrated on these issues properly, during teaching measurement tools practical work should be done, during lectures the more concrete examples should be preferred and the concepts should be linked with daily life experiences.

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