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What Do Science Teacher Candidates Know About Measuring Instruments and Units?*

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Abstract

Problem Statement: It is unknown how Science Teacher Candidates (STCs) recognize measuring instruments and indicate units that STCs will teach to their students, which they will constantly come across when they become teachers. Determining this case is important because it is believed that the results of this study will support the implementations that provide them with the ability to improve their measuring skills during their undergraduate programs.

Purpose of the Study: The aim of this study is to determine how knowledge of STCs, in regard to measuring instruments and the units of qualities measured by these instruments, change according to their grades.

Method: The sample of this study, which was carried out according to cross-sectional research methodology, was comprised of 259 STCs (freshmen [N = 58], sophomores [N = 68], juniors [N = 67], and seniors [N = 66]) at the department of elementary science teacher education in the faculty of education of a state university. The Measuring Instruments and Units Questionnaire (MIUQ), which is comprised of 17 measuring instruments that take place in science education programs and textbooks

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for primary schools and their units, was used as a data collection tool in the study. The data gathered from the study was analyzed through content analysis.

Findings: Ninety-five percent of senior STCs answered correctly Celsius (^{o}C) and Kelvin as units of temperature. Sixty-one percent of sophomore STCs answered heat as the quality measured by the calorimeter. Eighty-four percent of junior STCs did not provide an answer for the unit of heat. However, 64% of freshmen STCs stated weight as the quality measured by the bascule; 60% of them stated kg as the unit of weight. Ninety-one percent of junior, 82% of senior, 69% of freshmen, and 60% of sophomore STCs did not answer the quality measured by the manometer. Seventy-nine percent of freshmen and 72% of junior STCs did not answer the unit of quality measured by the graduated cylinder. Five percent of senior and 3% of sophomore STCs stated that the "V" symbol is the unit of speed.

Conclusions and Recommendations: In the study, it was determined that STCs are misinformed about the qualities measured by measuring instruments, and they lack knowledge regarding the units of measured qualities. It is concluded that their knowledge of measuring instruments and units does not increase parallel to their grades.

Key words: Science education, measuring instrument, measuring quality, unit, science teacher candidate, cross-sectional research.

Introduction

"Temel decides to carry out an experiment with a xenopsylla. First, he breaks one of the legs of the xenopsylla and orders it;

- Jump!

The xenopsylla jumps. Temel breaks the other leg of the xenopsylla and orders;

- Jump xenopsylla!

The xenopsylla jumps again. Then, Temel breaks all the legs of the xenopsylla and orders;

-Jump xenopsylla!

The xenopsylla does not jump this time. Temel orders it to jump again, but the xenopsylla does not move and Temel concludes that;

The xenopsylla that loses one leg jumps, the xenopsylla that loses two legs jumps, but the xenopsylla that loses all legs goes deaf."

Just as in the anecdote above, individuals who are not able to use their science process skills are likely to come to wrong conclusions. In science education, students' science process skills are quite important in order for them to gather scientific information. Thus, teaching them how to catch a fish instead of just handing one over is a necessary upskill.

Measuring is a science process skill that takes place among the basic skills (Lancour, 2008; Padilla, 1990). Measuring is an important skill for an individual when learning the differences among concepts of science as well as becoming a scientific literate. Measuring is the act of giving meaning to quantitative observations by comparing them with the set standards (Arthur, 1993).

Measuring starts by determining the quality and quantity that will be measured and selecting a suitable measuring instrument and measuring unit (Beichner & Serway, 2000). In this regard to upskill in measuring, an individual first needs to know which quality is to be measured, by which measuring instrument, and how they are reflected as a unit (Buxton & Provenzo, 2007; Carin & Bass, 2001). If this is not known, it is inevitable that individuals who measure the qualities that need to be measured will use the wrong measuring instruments, or they will reflect the measured quality through the wrong unit even if they have measured it with the right measuring instrument.

Individuals formally learn first-time upskill in measuring during their pre-school education (Klahr, 2000). Implementations for upskilling in measuring and improving these skills take place in other educational programs as well (Maral, Oguz-Unver & Yurumezoglu, 2012). Research indicates that primary school students (Koray, Ozdemir & Tatar, 2005), secondary school students (Anilan, 2014; Yildirim & Ilhan, 2007; Yucel, Secken & Morgil, 2001), and university students (Cildir, 2012; Secken, Yucel & Morgil, 2002) have deficiencies when measuring and reflecting the measured qualities by unit. Hence, it is quite important to introduce and teach measuring instruments and units of the qualities to individuals. There is no doubt that teachers have an important mission and responsibility regarding students' upskill in measuring as well as teaching units. Teachers should exhibit exemplary behavior to their students because model teachers support students' learning (Germann, Aram & Burke, 1996). When teachers retain wrong information, it is inevitable that they will share it with their students by carrying it to their learning environments (Emrahoglu & Ozturk, 2009). When this situation is taken into account, the determination of STCs' knowledge regarding measuring instruments, as well as the units of the qualities that are measured by these instruments, is important. It is believed that the results of this study will support the implementations that provide STCs the ability to improve their measuring skills during their undergraduate programs. STCs take several laboratory, science, and science teaching courses during their undergraduate programs (URL, 2016). Nevertheless, it is unknown how STCs recognize measuring instruments and indicate the units they will teach to their students when they become teachers. A question to be considered is, "What do STCs know about measuring instruments and units, and how does this knowledge of STCs change according to different grades?" It is believed that the results of this study will emphasize the teaching of measuring instruments and unitize the measured quality according to the system international of units.

The aim of this study is to determine how STCs' knowledge regarding measuring instruments and units of the qualities are measured, as well as how these instruments change according to their grades.

Method

Research Design

This study was carried out according to cross-sectional research methodology. Cross-sectional research is a process in which instant information is gained about the sample in a certain period of time. In cross-sectional research, the sample is generated by groups chosen simultaneously from a population (Cohen, Manion & Morrison, 2007; Sahin, 2014).

Research Group

The study group consisted of 259 STCs (freshmen [N = 58], sophomores [N = 68], juniors [N = 67], and seniors [N = 66]) in the elementary science teacher department of the education faculty at a state university.

Research Instrument and Procedure

The Measuring Instruments and Units Questionnaire (MIUQ) was used as a data collection tool. While developing the MIUQ, the course books approved by the Ministry of National Education—and used for science courses of fifth to eighth graders in elementary school in 2013–2014 as well as the elementary school science teaching program—were analyzed. Content of the MIUQ, which consists of measuring instruments and units, was determined from the science course books, according to these analyses (MNE Comission, 2012; MNE Comission, 2013a; MNE Comission, 2013b; Tunc, Bakar, Basdag, Ipek, Bagci, Gursoy Koroglu, Yoruk & Keles, 2012). In the MIUQ, 17 measuring instruments were listed in the column of a table. The STCs requested that the quality measured by the measuring instrument and the units of that measured quality be stated. The views of three science education experts were consulted for validity of the MIUQ. Before the MIUQ was applied, the pilot study was carried out with 10 STCs.

Data Analysis

Data gathered from the MIUQ was analyzed contently. The data was coded as Correct (T), Alternative Concept (AC), False (F), Concept (C), Unit (U), Symbol (S), Unrelated (Ur), and No Comment (NC), and the frequency of code usage was determined. To provide the validity of the codes, the researchers decided these codes by consensus. To correctly compare according to the STCs' grades, the percentage values were calculated according to the frequency of usage. While calculating the percentage values, the number of STCs who participated in the study in each grade was taken into account. The explanations of the codes are presented in Table 1..

Table 1.

Codes in the Data Analysis, Content, and Quoted Statements

Codes	Content	Quoted statements that describe the coding
Correct (C)	The answers are scientifically correct.	"An equal-arm balance scale is the measuring instrument used to measure mass." "The unit of mass is g."
Alternative Concept (AC)	The answers are not accepted scientifically and define another concept	"A thermometer is used to measure heat." "The unit of temperature is the joule."
False (F)	Answers with no scientific meaning	"The unit of quality measured with a dynamometer is $kg/m.s^2$."
Concept (C)	The statement of the concept of the measured quality	"A voltmeter measures voltage."
Unit (U)	Expresses the measured quality with a unit	"A calorimeter measures calories."
Symbol (S)	Expresses the unit of the measured quality by the symbol of the quality	"The unit of quality measured by a calorimeter is Q."
Unrelated (Ur)	The definitions do not have any relation to the quality and answers as the repetition of the question	"Beakers are used to measure while the solution is prepared in the laboratory."
No Comment (NC)	The situation that no comment exists	

Results

Findings were presented by taking into account the measuring instruments related to concept dualities, which learners sometimes confuse with each other in the tables. For example, learners often confuse heat-temperature concepts, so findings related to the thermometer and calorimeter are presented together in Table 2.

Table 2.

Findings related to the *Thermometer and Calorimeter*

MI	Codes	Quality	Percent (%) G1	G2	G3	G4	Codes	Units	Percent (%) G1	G2	G3	G4
Thermometer	C	Temperature	95	97	100	86	T	°C	84	43	85	95
	AC	Heat	2	3	-	2		K	29	6	27	21
	NC		3	-	-	12	AC	J	-	-	4	-
								Cal	-	1	-	-
							S	Temperature (T)	3	-	1	-
							NC		12	56	10	5
Calorimeter	T	Heat	34	44	61	38	T	cal , kcal	12	13	46	32
		Energy	12	6	9	14		J , kJ	19	3	15	18
	AC	Temperature	5	1	3	-	AC	°C	5	-	1	2
		Nutritional value	5	5	1	4		K	2	-	-	-
	Br	Calorie	10	24	9	14		cal/g.°C	-	-	4	-
	NC		33	19	16	32	S	Heat(Q)	2	-	-	2
							F	C/cal, K/cal, cal/g	-	-	10	2
							NC		69	84	36	53

Table 2 shows that 100% of junior STCs answered temperature as the quality measured by the thermometer. Ninety-five percent of senior STCs answered correctly °C and Kelvin as the units of temperature. Sixty-one percent of junior STCs answered heat as the quality measured by the calorimeter. Eighty-four percent of sophomore STCs did not provide an answer for the unit of heat. Findings related to the dynamometer, hand scale, equal-arm balance scale, and bascule are presented in Table 3.

Table 3.

Findings related to the *Dynamometer, Hand Scale, Equal-Arm Balance Scale, and Bascule*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Dynamometer	C	Weight	26	32	72	41	T	N, kg.m/s^2	21	9	73	70
		Force	24	16	19	47		dyn, g.cm/s^2, gF	2	-	13	6
	AC	Pressure	3	21	6	2	AC	g, kg	21	4	18	17
		Mass	2	-	4	8		m/s, m/s^2	2	3	-	-
		Power	9	-	1	-		N.m , J	2	-	-	2
		Heat	-	1	-	-		Watt	3	-	-	-
	NC		38	32	1	3	S	Force (F)	3	-	1	-
								Weight (G)	-	1	1	2
								Pressure (P)	-	1	1	2
							F	kg/s, kg/m.s, g.cm/s, kg/m.s^2	-	-	10	12
							NC		50	75	12	15
Hand scale	C	Weight	10	21	31	26	T	N, kg.m/s^2	-	1	13	11
		Force	67	38	51	58		dyn , gF	-	-	1	2
	AC	Mass	-	-	1	3	AC	g , kg, ton	90	26	79	70
	NC		22	41	16	15	S	Mass (m)	5	-	-	3
							NC		26	78	34	38
Bascule	D	Weight	64	32	52	53	T	N , gF	-	-	7	8
	AC	Mass	12	40	39	23	AC	g	28	3	36	30
		Pressure	-	-	-	2		kg	60	22	57	50
	NC		24	43	9	9		Pa	-	-	-	2
								ml , cm^3	-	-	3	-
							S	Mass (m)	2	-	-	2
							NC		31	78	30	38
Equal-arm balance scale	C	Mass	10	25	66	48	T	g	52	18	70	52
	AC	Weight	50	31	24	32		kg	22	16	46	47
	Ur	19	29	9	15			mg	10	7	-	3
	NC		19	15	1	5	AC	N	-	1	7	-
							S	Mass (m)	-	-	3	5
							NC		26	66	12	21

Table 3 shows that 72% of junior STCs answered weight as the quality measured by the dynamometer. Seventy percent of senior STCs answered "N" or kg.m/s^2, and 21% of freshmen STCs stated g or kg as units of weight. Sixty-seven percent of freshmen STCs answered force as the quality measured by the hand scale. Ninety percent of freshmen STCs stated g, kg, or ton as units of weight. Similarly, 79% of junior and 70% of senior STCs stated g, kg, or ton as units of weight in the AC code. Seventy-eight percent of sophomore STCs did not provide an answer. Sixty-six percent of junior STCs answered mass, and 50% of freshmen STCs stated weight as the quality measured by the equal-arm balance scale. However, 52% of freshmen STCs stated g as the unit of mass. However, 64% of freshmen STCs stated weight as the quality measured by the bascule, and 60% stated kg as the unit of weight. Likewise, 57% of junior and 50% of senior STCs stated kg as the unit of weight in the AC code. Findings related to the ampere meter, resistivity meter, and voltmeter is presented in Table 4.

Table 4.

Findings related to the *Ampere Meter, Resistivity Meter, and Voltmeter*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Ampere meter	C	Current	71	75	85	88	T	A	31	25	54	44
	AC	Voltage	5	3	-	-		mA	3	1	1	-
		Pressure	2	-	4	2		kA	2	-	-	-
		Lux	-	3	-	-	AC	Ohm	5	-	9	5
		Electrical Power	-	-	1	-	S	Current (I)	2	4	12	12
	U	Ampere	10	15	6	2	NC		62	68	24	35
	NC		12	4	3	9						
Voltmeter	C	Voltage	24	47	55	52	T	V	34	26	58	42
	AC	Current	24	25	6	9		Ohm.A	-	-	1	-
		Resistance	10	4	4	3	C	Voltage	-	1	4	8
		Electrical power	9	3	1	-	AC	Ohm	2	-	-	-
		Electrical energy	7	-	1	2		Watt, kWatt	7	1	1	2
		Light intensity	-	3	-	-		Joule	-	-	1	-
	U	Volt	16	15	18	12	NC		62	68	31	44
	NC		10	3	13	23						
Resistivity Meter	C	Resistance	45	49	78	59	T	Ohm, V/A	21	10	34	27
		Electricity	5	4	3	2	AC	Ampere	-	-	1	-
	AC	Current	7	4	4	5		Volt	-	-	1	2
		Voltage	3	-	-	2	S	Resistance (R)	5	4	4	14
	U	Ohm	2	-	-	-		Current (I)	-	-	1	3
	NC		38	44	15	33	NC		74	85	57	53

Table 4 shows that 88% of senior and 71% of freshmen STCs answered current as the quality measured by the ampere meter. Forty-four percent of senior STCs answered correctly "A" as the unit of current; 62% of freshmen did not provide an answer. Fifty-five percent of junior and 52% of senior STCs answered voltage/potential difference as the quality measured by the voltmeter; 68% of sophomore and 62% of freshmen STCs did not answer the unit of current. Seventy-eight percent of junior STCs answered correctly resistance as the quality measured by the resistivity meter; 85% of sophomore and 74% of freshmen STCs did not answer the unit of resistance. Findings related to the barometer and manometer are presented in Table 5.

Table 5.

Findings related to the *Barometer and Manometer*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Barometer	C	Open-air pressure	12	7	4	14	T	Atm	11	4	13	7
	AC	Gas pressure in a container	3	-	4	-		Bar	2	-	4	1
		Gas pressure	10	7	9	3		Bari	-	-	-	1
		Pressure	43	43	57	56		mmHg	4	-	1	2
		Air flow	-	-	1	2		cmHg	1	1	2	-
		Height of mercury	-	-	-	2		Pa	1	1	17	8
	NC		31	43	24	24	AC	N	-	-	1	-
							S	Pressure (P)	2	1	7	6
							NC		39	61	29	41
Manometer	C	Gas pressure in a container	7	-	1	11	T	Atm	2	1	8	2
	AC	Air pressure	7	1	3	2		Bar	-	-	-	1
		Open-air pressure	7	-	18	2		mmHg	4	1	-	-
		Pressure	10	3	13	3		cmHg	4	-	1	-
		Liquid pressure	-	3	4			Pa	-	-	4	1
	Ur		-	1	-	2	AC	N	-	-	1	-
	NC		69	91	60	82	S	Pressure(P)	-	-	2	2
							NC		51	66	42	59

Table 5 shows that 57% of junior and 56% of senior STCs answered pressure as the quality measured by the barometer in the AC code. Seventeen percent of junior STCs answered correctly Pa as the unit of open-air pressure; 41% of senior STCs did not provide an answer. Ninety-one percent of sophomore, 82% of senior, 69% of freshmen, and 60% of junior STCs did not answer the quality measured by the manometer. They also did not answer the unit of gas pressure in a container. Findings related to the beaker and graduated cylinder are presented in Table 6.

Table 6.

Findings related to the *Beaker and Graduated Cylinder*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Beaker	C	Volume	14	6	48	26	T	mL	24	21	58	39
	AC	Liquid mass	16	12	4	15		L	21	16	33	20
		Liquid weight	2	-	-	-		cm^3	3	-	9	5
		Height of matter	7	-	-	3		m^3	2	-	4	5
	NC		28	35	13	50		cc	-	-	1	-
							ACS	mm, cm	5	1	1	14
								g, kg	5	-	1	3
								Volume (V)	3	-	1	3
							NC		53	69	22	33
Graduated cylinder	C	Liquid volume	2	6	28	11	T	mL	16	12	61	42
		Volume	10	4	24	15		L	10	4	33	24
		Solid volume	-	-	-	2		cm^3	2	4	13	11
	AC	Liquid mass	5	9	16	18		m^3	2	1	4	5
		Liquid pressure	-	-	-	2		cc	-	-	1	-
	Ur		38	32	16	33	ACS	g, kg	-	-	-	3
	NC		45	49	15	20		mm, cm	2	1	1	11
								Pa	-	-	-	2
								Volume (V)	3	-	1	3
							NC		72	79	15	26

Table 6 shows that 48% of junior STCs answered correctly volume as the quality measured by the beaker; 58% and 33% answered correctly mL and "L" as the units of volume. Not only did 50% of senior STCs not answer the quality measured by the beaker, but 14% of them also stated mm or cm as the units of volume in the AC code. Thirty-eight percent of freshmen STC answers regarding the quality measured by graduated cylinder are in the Ur code. Also, 79% of sophomore and 72% of freshmen STCs did not answer the unit of quality measured by the graduated cylinder. Findings related to the speedometer are presented in Table 7.

Table 7.

Findings related to the *Speedometer*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Speedometer	C	Speed	9	9	13	2	T	m/s	22	7	16	21
	AC	Velocity	64	46	54	53		cm/s	3	1	7	3
		Time	3	-	3	5		km/s	5	4	10	3
		Distance	-	6	1	-		m/h	-	-	1	2
		Acceleration	-	-	6	-		km/h	14	6	6	9
	Ur		-	-	1	-	AC	h , s	5	-	1	9
	NC		22	41	21	39		m , km	10	4	6	3
								cm/s^2, m/s^2	3	3	13	6
							S	Velocity (V)	-	1	**3**	**5**
							NC		57	76	49	55

Table 7 shows that 64% of freshmen STCs stated velocity as the quality measured by the speedometer in the AC code. Five percent of senior and 3% of junior STCs stated the "V" symbol as the unit of speed. Findings related to the decibel meter are presented in the Table 8.

Table 8.

Findings related to the *Decibel Meter*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Decibel meter	C	Sound	14	9	10	18	T	dB	14	4	30	21
	AC	Volume	17	21	22	14	AC	Hz, mHz	7	-	1	9
		**Sound characteristics	17	6	16	18		m, cm	-	3	-	2
		Depth	-	1	3	-		cd	-	1	-	-
		Length	3	-	1	3	NC		79	91	69	68
		Seismic intensity	3	-	-	-	**Sound characteristics: Wave, vibration, frequency, level, speed, and pressure characteristics...						
		Light	-	1	-	-						
	NC		43	63	46	47						

Table 8 shows that 18% of senior STCs answered sound as the quality measured by the decibel meter in the AC code; 21% answered dB as the unit of sound. Sixty-eight percent did not provide an answer. Findings related to the chronometer are presented in Table 9.

Table 9.

Findings related to the *Chronometer*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Chronometer	C	Time	100	100	100	100	T	S	85	80	95	90
								Split-second	75	60	80	15
								Minute	90	85	97	92

Table 9 shows that all STCs answered correctly time as the quality measured by the chronometer, and s, split-second, and min as the units of time. Findings related to the ruler are presented in Table 10.

Table 10.

Findings related to the *Ruler*

MI	Codes	Quality	Percent (%)				Codes	Unit	Percent (%)			
			G1	G2	G3	G4			G1	G2	G3	G4
Ruler	C	Length	100	100	100	100	T	m	72	31	79	68
								cm	53	10	55	70
								mm	9	60	10	12

Table 10 shows that all STCs answered length as the quality measured by the ruler, and m, cm, and mm as the units of time.

Discussion and Conclusion

The results of this study indicate that STCs confuse qualities measured by measuring instruments. The reason for this is because they have alternative concepts about heat-temperature, weight-mass, current-voltage-resistance, open-air pressure-gas pressure in a closed container, and speed-velocity. The literature also indicates that students confuse these dual concepts: heat-temperature (Aydogan, Gunes & Gulcicek, 2003; Baser, 2006), mass-weight (Koray & Tatar, 2003; Koray et al., 2005), and speed-velocity (Yildiz, Buyukkasap, Erkol & Dikel, 2007). For example, in answers of freshman to senior STCs, the alternative concept is "the thermometer measures heat." In addition, it was found that STCs do not recognize the calorimeter as a heat-measuring instrument; they state "nutrition value" as the quality measured by the calorimeter. Parallel to this situation, they confuse units of quality measured by the measuring instruments. STCs' statements are "equal-arm balance scales measure weight" and "the dynamometer and hand scale measure mass," which indicates that STCs confuse the concepts of weight with mass; they expressed that the "unit of weight is kg" or the "unit of mass is N." These results support those of other research regarding seventh-grade students (Koray et al., 2005) and high school students (Yildirim & Ilhan, 2007; Yucel et al., 2001), who confused weight and mass measuring instruments and units.

This situation can stem from the improper usage of units of quality measured by measuring instruments in daily life. Individuals weigh out with bascules and read the results of measurements as kilogram on displays. This situation stems from its production. Bascules measure weight, but results of the measurement are presented to users after they are compared with gravitational acceleration. Although the hand scale also measures weight as a working principle, there are mass units. Therefore, although the grades of the students improve, it is not possible for them to forget the alternative concepts as long as they keep using measuring instruments with the wrong units. Therefore, this situation should be explained to students.

The STCs also confused symbols with units of qualities measured. For example, the STCs stated "T" as the symbol for the unit of temperature, or "R" for the unit of resistance. This could be because STCs do not know science concepts in English. For example, if an STC knows that "basinc" in Turkish is "pressure" in English, they can easily comprehend that the symbol is the first letter of the related concept in English. As a result, confusion between the unit and symbol can be prevented. STCs may confuse the abbreviation of the Pascal (Pa) with the symbol of pressure (P). Contrary to this result, Anilan (2014) found that high school students generally know the units and symbols used in science classes.

When STCs' alternative concepts regarding the unit of quality measured by the dynamometer (kg/s, kg/m.s, g.cm/s, kg/m.s^2) were examined, it was found that STCs have problems with the derivative unit. To help learners construct the derivative units in the right way, it is recommended that applications for analyzing derivative units (N=kg.m/s^2) take place in science classes. In addition, STCs generally use the units in the MKS more than other unit systems, and they use the units in the CGS unit system less. This situation may be the result of the fact that STCs calculate according to the MKS unit system. In this regard, STCs should be provided learning activities that consist of the transformation of the same units between the MKS and CGS unit systems.

It is also obvious that there is an incompatibility between the answers they have given for the qualities and their units. This situation gives rise to the thought that STCs have memorized the units. The STCs mentioned that both the quality measured by the ampere meter and the units are totally different from each other, which indicates that they have memorized them without constructing any reasonable relations.

When the answers of STCs were compared to their grades, an increase was found in the frequency of correct usage of the expressions in the answers given regarding the thermometer, dynamometer, calorimeter, hand scale, equal-arm balance scale, bascule, ampere meter, voltmeter, resistivity meter, beaker, and graduated cylinder. Nevertheless, it is remarkable that this increase is not systematic for all of the measuring instruments. Contrary to this situation, there is not a decrease in the usage frequency of alternative concepts regarding the units in STCs' answers according to their grades. Similar alternative concepts are generally stated in each grade. Koray and Tatar (2003) have detected that sixth-, seventh-, and eighth-grade students also have similar alternative concepts in regard to concepts and units of force and weight; however, they are being taught at the elementary or fourth-grade level. As long as the alternative concepts that students have in primary school are not removed, it isn't a surprise to come across students with alternative concepts in their future education processes. The confusion of freshmen to senior STCs can be explained by the fact that alternative concepts were obtained in former grades or are intuitively resistant to change. Some alternative concepts detected before teaching cannot even be removed through applications used for removing alternative concepts (Ipek-Akbulut, Sahin & Cepni, 2013).

Even this situation may prevent students from upskill measuring. In addition, no differences were determined between the STCs' grades regarding the findings of the barometer, manometer, speedometer, and decibel meter. The reason for this may be because they are not used frequently in the laboratory or daily life. One explanation is that students' upskill measuring is related to the frequency of measuring instruments' usage. Similarly, Cildir (2012) determined that physics teacher candidates do not regard themselves as sufficient when using measuring instruments like the vernier caliper and micrometer, which are used in mechanic's laboratories; this is because the above-mentioned measuring instruments are not frequently used. In this study, the rates of correct answers from the STCs—from all grades regarding their units and the quality of measures by the hand scale and equal-arm balance scale—are close to each other. This may be identified by the fact that those measuring instruments are used frequently in daily life. Likewise, Maral et al. (2012) emphasized in their research that it is important to upskill measure not only one's usage of measuring knowledge and skill, but also the repetition of the measurement process. It is recommended that activities that encourage STCs and other students to use measuring instruments in laboratories should take place.

This situation may result from the fact that affecting variables of learning process differs according to the lecturers' sensibility of the STCs' recognition of measuring instruments and units of measured qualities, as well as the content of the education they have received. In their education process, it is possible that STCs receive related courses from different lecturers; therefore, the sensibility shown by each lecturer regarding the recognition of measuring instruments and their units may be different. It is recommended that activities that contain cognitive, affective, and psychomotor qualities to help STCs recognize and discover measuring instruments and their units should be prepared and applied to remedy their lack of knowledge.

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Fen Bilgisi Öğretmen Adayları Ölçme Aletleri ve Birimler Hakkında Ne Biliyorlar?

Atıf:

Hacioglu, Y., Durukan, U. G. & Sahin, C. (2016). What do science teacher candidates know about measuring instruments and units? *Eurasian Journal of Educational Research*, 64, 287-306
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Özet

Problem Durumu: Fen bilimlerinde öğrencilerin bilimsel bilgiye ulaşmalarında bilimsel süreç becerileri oldukça önemlidir. Temel Bilimsel süreç becerilerinden birisi olan ölçme ise, bireyin hem fen öğrenirken kavramlar arası farklılıkları öğrenebilmesi, hem de fen okuryazarı olabilmesi için önemli bir beceridir. Ölçme işlemi; ölçülecek nitelik ve niceliğin belirlenerek uygun ölçme aracının ve ölçme biriminin seçilmesi aşamaları ile başlar. Bu bağlamda bireylerin ölçme becerisini kazanmaları için öncelikle hangi niteliğin hangi ölçme aleti ile ölçüldüğünü ve birim olarak nasıl ifade edildiğini bilmesi gerekmektedir. Fakat alan yazında yapılan çalışmaların sonuçlarında bireylerin ölçmede ve ölçülen niteliği birimle ifade etmede önemli eksiklikleri olduğu görülmektedir. Bireylere ölçme aletleri ile bu aletlerin ölçtüğü niteliklere ait birimlerin tanıtılması ve öğretilmesi oldukça önemlidir. Dolayısı ile fen bilimleri dersinde öğrencilere ölçme becerisini kazandıracak, ölçme aletlerini ve ölçü birimlerini tanıtacak ve öğretecek fen bilgisi öğretmenlerine de önemli sorumluluklar düşmektedir. Bu durum dikkate alındığında; fen bilgisi öğretmen adaylarının lisans eğitimleri sürecinde ölçme aletlerini tanıması, bu ölçme aletleri ile ölçülen niteliğin birimleri hakkındaki bilgilerinin belirlenmesi onların ölçme becerilerini geliştirmelerini sağlayıcı uygulamalara temel oluşturması açısından oldukça önemlidir.

Araştırmanın Amacı: Bu çalışma, fen bilgisi öğretmen adaylarının ölçme aletleri ile bu ölçme aletleri ile ölçülen niteliğe ait birimler hakkındaki bilgilerinin sınıf seviyesine göre nasıl bir değişiklik gösterdiğini belirlemek amacıyla yapılmıştır.

Araştırmanın Yöntemi: Enlemsel araştırma desenine göre yürütülen araştırmanın örneklemini, bir devlet üniversitesinin eğitim fakültesinde öğrenim görmekte olan ilköğretim fen bilgisi öğretmenliği; 1. sınıf (N=58), 2. sınıf (N=68), 3. sınıf (N=67) ve 4. sınıf (N=66) olmak üzere toplam 259 öğretmen adayı oluşturmaktadır. Araştırmada veri toplama aracı olarak ilköğretim fen bilimleri öğretim programı ve ders kitaplarında yer alan 17 ölçme aletinden oluşan "Ölçme Aletleri ve Birimler Anketi (ÖLABA)" kullanılmıştır. Anketten elde edilen veriler içerik analizi ile çözümlenmiştir. Veriler; Doğru (D), Alternatif Kavram (AK), Yanlış (Y), Kavram (K), Birim (Br), Sembol (S), İlgisiz (İ) ve Görüş Bildirmedi (GB) olarak kodlanmış ve kodlara ait kullanım sıklığı belirlenmiştir.

Araştırmanın Bulguları: Dördüncü sınıf Öğretmen adaylarının (ÖA) tamamı termometrenin sıcaklık ölçtüğünü ve %95'i sıcaklığın birimini olan santigrat derece (^oC) ve Kelvin cevabını doğru olarak vermişlerdir. Ayrıca üçüncü sınıf ÖA'ların %61'i kalorimetrenin ısı ölçtüğünü belirtmişlerdir.. İkinci sınıf ÖA'ların % 84'ü ise ısının birimini cevaplayamamışlardır.. Üçüncü sınıf ÖA'ların %72'si dinamometrenin ağırlık ölçtüğü cevabını vermişlerdir. Dördüncü sınıf ÖA'ların %70'i ağırlığın birimini N veya $kg.m/s^2$ şeklinde doğru olarak belirtmişlerdir. ÖA'ların çoğu ağırlığın birimini kütlenin birimleri olan g ve kg ile karıştırmışlar ve alternatif kavram kodunda cevap vermişlerdir. Birinci sınıf ÖA'ların %64'ü baskülün ölçtüğü niteliği ağırlık olarak belirtmelerine rağmen, ağırlığın birimini %60 oranında kg olarak belirtmişlerdir. ÖA'ların çoğu ampermetrenin elektrik akımını ölçtüğü doğru cevabını verirlerken, birinci ve ikinci sınıf ÖA'lar sırasıyla %62 ve 68% oranında akımın birimini belirleyememişlerdir. Voltmetrenin elektriksel potansiyeli ölçtüğünü üçüncü ve dördüncü sınıflar sırasıyla %86 ve %88 oranında doğru cevaplandırmalarına rağmen, ÖA'larının büyük çoğunluğu gerilimin birimini Volt olarak belirtememişlerdir. Benzer durum ÖA'ların direnç ölçerin ölçtüğü nitelik ve birimi ile ilgili cevaplarında da görülmektedir. ÖA'lar barometrenin ölçtüğü niteliği açık hava basıncı olarak belirtemezlerken, üçüncü ve dördüncü sınıf ÖA'ların barometrenin basınç ölçtüğünü sırasıyla %57 ve %56 ve basıncın birimini Pa olarak sırasıyla %17 ve %8 oranlarında belirtmişlerdir. ÖA'ların çoğu manometrenin kapalı kaptaki basıncı ölçtüğünü ve birimlerini cevaplandıramamışlardır. Üçüncü sınıf ÖA'ların %28'i dereceli silindirin hacim ölçtüğünü ve % 61'i hacim birimini mL olarak doğru olarak cevaplamışlardır. Dördüncü sınıf ÖA'ların %14'ü beherin ölçtüğü niteliğin birimini AK kodunda mm, cm olarak belirtmişlerdir. Birinci sınıf ÖA'ların %64'ü AK kodunda sürat göstergesinin hız ölçtüğü cevabını vermişlerdir. Dördüncü sınıf ÖA'ların %5''i ise süratin birimi olarak hızın sembolü olan V'yi ifade etmişlerdir. Dördüncü sınıf ÖA'ların %18'i desibel metrenin ses ölçtüğünü belirtirken, üçüncü sınıfların %30'u dB birimi ile ifade edildiğini belirtmişlerdir. Öğretmen adaylarının tamamı kronometrenin zamanı ölçtüğünü ve cetvelin uzunluk ölçtüğünü belirtmişler ve zaman ve uzunluk birimlerini doğru ifade etmişlerdir.

Araştırmanın Sonuçları ve Önerileri: Araştırmada öğretmen adaylarının ölçme aletlerinin ölçtüğü nitelikle ilgili yanlış bilgilere ve ölçülen niteliğin birimleri ile ilgili bilgi eksikliklerine sahip oldukları belirlenmiştir. ÖA'ların ölçme aletleri ile ölçülen nitelikle ilgili cevapları; onların ısı-sıcaklık, ağırlık-kütle, akım-gerilim-direnç, açık hava basıncı-kapalı kaptaki gaz basıncı, sürat-hız kavramlarını birbiri ile karıştırdıklarına işaret etmektedir. Ayrıca ÖA'ların ikili kavram çiftlerini birbirine karıştırmalarının bir sonucu olarak, bu kavramlarla ilgili birimleri de birbirine karıştırdıkları söylenebilir. Bu sonuç bireylerin ölçme becerilerini kazanmasında da büyük bir engel teşkil etmektedir.

ÖA'ların ölçülen niteliğin birimini belirleme konusunda yaşadıkları güçlüklerden birisi de, birim ifadesi yerine kavrama ait sembolleri kullanmalarıdır. Bu durumun sebebi, ÖA'ların fen kavramlarının İngilizce isimlerini bilmediklerinden kaynaklanabilir. Örneğin ÖA eğer basıncın İngilizce karşılığının "Pressure" olduğunu bilirse sembolün ilgili kavramın İngilizce adının ilk harfi olacağını zihninde daha iyi yapılandırabilir. Böylece sembol ile birimin karıştırılmasının önüne geçilebilir.

Ayrıca ÖA'ların türetilmiş birimleri yazarken de problem yaşadıkları görülmektedir. Örneğin ÖA'lar Newton birimini, kütle (kg) ve yer çekimi ivmesinin (m/s^2) çarpımı şeklinde yazmaya çalıştıkları ve bunu yazarken de başarılı olamadıkları görülmektedir. Öğrencilerin türetilmiş birimleri doğru bir şekilde yapılandırmaları için fen derslerinde türetilmiş birimlerle ilgili uygulamalara yer verilmesi önerilmektedir.

ÖA'ların ölçülen niteliğe verdikleri yanıt ile niteliğe ait ifade ettikleri birimler arasında bir uyuşmazlık olduğu dikkat çekmektedir. Örneğin, ÖA'lar ampermetrenin gerilim, ışık şiddeti, elektrik gücü ölçtüğü şeklinde cevaplar vermelerine rağmen, niteliğin birimine yönelik sadece direnç birimini yazmışlar ya da görüş bildirmemişlerdir. Bu durum ÖA'ların birimleri ezberlemiş olabileceklerini düşündürmektedir

ÖA'ların doğru cevap olarak birim sistemleri arasında daha çok MKS birim sistemindeki birimleri kullanma eğiliminde oldukları ve CGS birim sistemindeki birimleri daha az kullandıkları tespit edilmiştir. Bu durum ÖA'ların öğretim sürecinde daha çok MKS birimlerini kullanmış olmalarından kaynaklanabilir.

ÖA'ların cevapları sınıf seviyelerine göre karşılaştırıldığında termometre, kalorimetre, dinamometre, el kantarı, terazi, baskül, ampermetre, voltmetre, direnç ölçer, beher, dereceli silindire yönelik verilen cevaplarda sınıf seviyesi ilerledikçe doğru ifadelerin kullanılma sıklığında bir artış olduğu görülmektedir. Fakat bu artışın tüm ölçme aletleri için düzenli bir şekilde olmadığı da dikkat çekmektedir. Bu durumun aksine, ÖA'ların özellikle de birimlere yönelik cevaplarındaki alternatif kavramlarının kullanım sıklığında sınıf seviyesine göre bir azalma da bulunmamaktadır. Ayrıca, ÖA'ların barometre, manometre, kronometre, sürat ölçer, cetvel ve desibel metre ile ilgili cevaplarında da sınıf seviyesine göre bariz bir değişim görülmemektedir. Bu durumun barometre, manometre gibi ölçme aletlerinin laboratuvar derslerinde çok sık kullanılmamasından kaynaklanabileceği

düşünüldüğünde, ÖA’ların ölçme becerilerinin gelişmesinde ölçme aletlerinin kullanılma sıklığının önemli bir belirleyici olabileceği sonucuna ulaşılabilir.

Tüm bu sonuçlar ışığında ÖA’ların ölçme aletleri ile birimlerini tanımalarına ve keşfetmelerine yönelik bilişsel, duyuşsal ve psikomotor nitelikleri barındıran etkinlikler hazırlanarak uygulanması ile ÖA’ların bilgi eksikliklerinin giderilmesi önerilmektedir.

Anahtar Kelimeler: Fen eğitimi, ölçme aletleri, ölçülen nitelik, birimler, öğretmen adayı, enlemsel araştırma.