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INVESTIGATING 12th GRADE STUDENTS' PRIOR KNOWLEDGE OF STATIC ELECTRICITY CONCEPTS

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Abstract
This study was aimed at describing the types of prior knowledge of the 12th-grade students on static electricity concepts. This study was done at public senior high schools in Singaraja Bali. There were 117 students who participated in the study, they were between 16-17 years old. The data of students' prior knowledge of static electrisity were collected by using Three Tier Diagnostic Static Electricity Test (TTDSET) with the index of reliability r= 0.61. The data analysis was done by descriptive technique. The result showed that the students' prior knowledge of static electricity concepts is very varied which can be categorized into four categories namely: Scientific Knowledge, Misconception, Lack Knowledge, and Error. The implication of the result in the teaching of physic is that the teacher needs to identify the student prior knowledge of static electricity concepts and design appropriate strategy of concept change.

Keywords: Prior knowledge, scientific knowledge, misconception, lack knowledge, error.

INTRODUCTION

It has been long since teachers received a teaching model that was based on a hidden assumption that knowledge could be transferred directly from the teacher's mind to the student's mind (Bodner, 1986). Hence, education focused on the effort to transfer knowledge from the teacher's mind to the students' mind. According to constructivism, knowledge is constructed in the mid of learner. The scientific theory is an understanding that is constructed by an individual interaction in the culture that defines a discipline, in this case, physical sciences (Chambers & Andre, 1997). Studies such as Orborne & Wittrock (1983); Driver et al (1994); Osborne et al. (1985); Maloney et al. (2001); Tekkaya (2002); Thompson & Logue (2006); Baser (2006); Küçüközer and Kocakülah (2007); and O'Dwyer (2009), show that the students enter the classroom not with empty minds, but they bring with them prior knowledge about science which is developed from daily experiences.

Prior knowledge is given various labels such as preconception (Turgut, Gürbüz & Turgut, 2011); children science (Bell, 1993; Osborn et al., 1985); alternative conception (Peterson, 2002) and misconception (Brown & Clement, 1989). Ausubel (1968) states that prior knowledge is a single factor which is the most important in influencing learning. Similarly, Ausubel, Hewson & Hewson (1983) show that one of the factors that influence student learning in science is students' prior knowledge, which can be in the form of alternative conception or also scientific conception. Prior knowledge is a knowledge that the student has before learning starts (Edinyang, 2006). Spesifically, Dochy and Alexander (1995) state that prior knowledge is all knowledge which is (1) dynamic, (2) available before learning,(3) structured, (4) can exist in various forms (i.e., declarative, procedural, and conditional knowledge), (5) explicit and implicit, and (6) contain component and metacognitive knowledge components.

According to constructivism, prior knowledge of the student plays an important role in developing student scientific knowledge. Prior knowledge can be viewed as naive theories that were difficult to change, as knowledge was developed base on everyday students' experiences, and as system account (Esanu & Hatu, 2015). Constructivism views learning as the construction and acceptance of new ideas or the reconstruction of existing ideas (Bell, 1993). During the learning, the students develop meaning based on background, attitude, and experiences (Pinarbasi, 2006). Many findings show that learning outcome especially comes from prior knowledge (Roschelle, 1997). A correct prior knowledge which is consistent with new knowledge has a positive effect on the development of scientific knowledge, on the contrary, the prior knowledge which is contradicting with new information has a negative effect (Svinicki,1993-1994). Dochy & Alexander (1995) differentiate the effect of prior knowledge into three categories 1) directly influence in facilitating learning, 2) the effect of the quality of prior knowledge (for example, incompleteness, misunderstanding, accessibility, number, availability and previous knowledge structure and 3) the interaction effect between quality and the effect facilitation.

The student prior knowledge can fit with scientific knowledge and there is also a prior knowledge that does not fit with scientific knowledge (Clement, Brown, & Zeitsman (1989). The prior knowledge which contradicts with the scientific concept is called misconception. The misconception that is brought by the student that contradicts with the scientific explanation (Broughton, Sinatra, and Reynolds, 2010), is resistant to changed, is very strong and difficult to changed by traditional teaching (Sungur, Tekaya & Geban, 2001). Misconception influences students to learn about new scientific knowledge and plays an important role in learning (Ozmen, 2007). The fact shows that misconception is the most important factor that gives a negative contribution to the students' academic success (Ozkan & Selcuk, 2012). Based on the description above, identification of the students' prior knowledge is important.

Studies on preconception (prior knowledge) of students about dynamic electricity have been done by many researchers such as Engelhardt & Beichner (2004), Turgut, Gürbüz, & Turgut (2011), Ismail et al. (2015), Sencar & Eryilmaz (2004), and O'Dwyer (2009). On the other hand, studies on the preconception about static electricity are still very limited such as Maloney et al. (2001) ; Bilal & Erol (2009); and Koudelkova & Dvorak (2015). Like dynamic electricity concept, static electricity concept is very important and is used frequently in daily life. Therefore, a correct understanding of static electrical concept becomes urgent. Based on this rationale, meaningful teaching on static electricity concepts at school should be developed. In an effort to enhance meaningful learning about static electricity, the identification of the types of student prior knowledge about static electricity needs to be done. The question that is answered in this study is "what does student prior knowledge look like concerning the concepts of static electricity?"

METHOD

Research Subject

This study was a descriptive study carried out at four public senior high schools in Singaraja Bali. The number of the students involved as the sample was 117, consisting of 40 males and 77 females. They were between 16-17 years old.

Data Collecting and Instrument

The data collected in this research were the types of students prior knowledge concerning static electricity concepts. The data were collected with a test technique. The instrument used was Three

Tier Diagnostic Static Electricity Test that is modified from Maloney et al. (2001) and Bilal & Erol (2009). This test consisted of three levels. The first level was a multiple choice that that asked the student to choose a correct answer from the alternative options answers. The second level was a multiple choice test that asked the students to choose an alternative reason that fitted with their choice at the first level. In this part, the students were also given the opportunity to write their reason if it was not found in the alternative option. The third part was the choice of the degrees of their certainty that the student has toward the answer and the reason that they have chosen. This part consisted of two alternatives, i.e., sure and not sure. This test had a reliability index of r=0.61. There were 25 items developed to identify the student prior knowledge of static electricity concepts. There are 25 items developed to identify the student prior knowledge of static electricity concepts. Table 1 shows the distribution of test items in static electricity subtopic.

Table 1: Distribution of Test items in static electricity subtopic

Static Electricity Sub concepts	**No item**
Electric charge	1, 2, 3, 4, and 5
Electrostatic Force	6, 7, 8, 9, 10, 11
Electric Field	12, 13, 14, 15, 16, 17
Electric Potential and Electric Potential Energy	18, 19, 20, 21, 22
Capacitor	23, 24, 25

Data Analysis

The data about the students' prior knowledge of static electricity concepts were analyzed descriptively. Qualitative analysis was used to describe the student conception categories into categories based on the result of TTDSET. Based on the result of TTDSET the students' prior knowledge was categorized into four categories: Scientific Knowledge; Misconception, Lack knowledge, and Error. The categorization was based on the combination of the student's responses in TTDSET in first, second and third levels as in Table 2. The student misconception types in each subconcept of electricity were described qualitatively and compared with what can be found in the literature of misconceptions.

Table 2: Categorization of the types of students answers

Aswer level 1	**Answer level 2**	**Answer level 3**	**Prior knowledge category**
True	True	Sure	Scientific Knolwledge (SK)
True	True	Not sure	Lack Knowledge (LK)
True	Wrong	Not sure	Lack Knowledge (LK)
Wrong	True	Not sure	Lack Knowledge (LK)
Wrong	Wrong	Note sure	Lack Knowledge (LK)
Wrong	True	sure	Error (E)
True	Wrong	Sure	Misconception (M)
Wrong	Wrong	Sure	Misconception (M))

Addapted from Kaltakci and Didis (2007)

FINDING

Categories of Students' Prior Knowledge

Before learning about static electricity at senior high school, the students had got a prior knowledge of static electricity concepts. Based on TTDSET the students' prior knowledge about static electrical concept could be classified into four categories: Scientific Knowledge (SK), Misconception (M), Lack Knowledge (LK), and Error (E). Table 3 shows the percentage of the students whose prior knowledge can be categories into the four categories.

Table 3: The average of percentage of Student categorized into SK, M, LK, and E for each static electricity subtopic

Static Electricity Concepts	SK			M			LK			E		
	Ma (%)	Fem (%)	Tot (%)	Ma (%)	Fem (%)	Tot (%)	Ma (%)	Fem (%)	Tot (%)	Ma (%)	Fem (%)	Tot (%)
Electric Charge	55.7	54.6	55.0	32.3	28,0	30,1	14.1	13.7	13.5	0.9	1.7	1.4
Electrostatic Force	10.3	9.3	9.7	52.5	46.9	49.2	33.3	35.0	34.3	6.0	7.4	6.9
Electric Field	17.7	18.1	18.0	27.3	30.7	29.4	51.1	54.7	47.9	5.3	4.5	4.8
Electric Potential	1.7	1.4	1.6	30.2	31.4	30.9	55.7	48.9	51.6	18.3	14.3	15.9
Capacitor	3.5	7.6	6.0	45.4	36.7	40.2	46.8	51.4	49.6	7.8	1.9	4.3
Mean (%)	17.8	18.2	18.1	37.5	34.4	35.9	40.2	39.0	39.4	7.7	6.0	6.6

Note: Ma = Male; Fe= Female.

Table above shows that in general: (1) on average, 18.1% students who consisted of 17.8% male and 18.2 % female had prior knowledge which was categorized as Scientific Knowledge; (2) 35.9 % students which consisted of 37.5% male and 34.4 % female had prior knowledge which was categorized as misconception; (3) 39.4% students which consisted of 40.2% male and 39.0% female lacked knowledge; and (4) 6.6% students who consisted of 7.7% male and 6.0% female had errors. The average of the percentage of the students with scientific knowledge mostly came from the students with scientific knowledge concerning electric charge, i.e., 55.0% consisting of 55.7% male and 54.6 % female. While the percentage of the students had prior knowledge of scientific knowledge type in other concepts such as electrostatic force, electric field, electric potential, and capacitor was in the range between 6.0% - 18.0%. On the other hand, the average of the percentage of the students who had the misconception about electrostatic force was 49.2% and capacitors 40.2%. The percentage of students who lacked knowledge was consecutively contributed by those who lacked knowledge in electrical potential, 51.6%, capacitor 49.6% and electric field 47.9%. The average of the percentage of students who had errors was mostly contributed by the students who had errors in electric potential, i.e., 15.7%.

Types of students' misconception in static electricity concepts

The qualitative analysis of the students' responses in TTDSET item shows the types of the students' misconceptions about static electricity concept as follows.

1. A balloon rubbed by silk will have the static electrical charge that it can attract paper torn pieces. The term static electricity is identical to a static charge.
2. Plastic rubbed by cloth will get additional electrons from the cloth, that the plastic charge becomes positive; the cloth will have the negative charge so that the cloth and the plastic will attract each other.
3. A neutral object has more neutrons then electrons and protons.
4. An object is called neutral if it has the same number of protons neutrons and electrons.
5. In an interaction between two objects with different charges, the object with more charge obtains a greater force than with the force proportional to its charge.
6. In an interaction between two objects with different charges, the object with a greater charge obtains a smaller force.
7. In an interaction between two charged particles, the particle with a greater charge exerts a greater force. This is similar to the finding of Bilal & Erol (2009).
8. In an interaction between two charges in which one has -2 units and +1 unit, and attractive force occur in which the +1 unit charge gets an attractive force by the -2 units charge with the charge twice the force obtained by the -2 units charge. The students drew the attractive force vector in the +1 charge twice as long as in the -2 unites charge.
9. In an interaction between two charges in which one has -2 units and +1 unit, repulsive force occurs in which the -2 unit charge obtains force twice as much as the +1 unit charge. The

students drew the vector of repulsive force in the -2 unit charge twice as long as the +1 unit charge.

10. In two objects with the same names but with different charges (for example +Q and +4Q), the objects with the smaller charge obtains a greater acceleration. In which the students equate charge with mass in Newton's second law.
11. In two objects with the same names but with different charges (for example +Q and 4Q), the object with greater charge obtains a greater acceleration.
12. The students do not do vector addition to obtain total force in the interaction between two charges or more.
13. A charge in a uniform electric field does not have acceleration. A similar misconception is also found in Bilal & Erol (2009), i.e., the particle charged in a uniform electric field moves at a constant speed.
14. A charged object that lies in a more densely electric filed lines obtains as smaller acceleration than if it is placed in less densely electric field line because of the denser the electric field line, the smaller its field strength.
15. In the parallel plate capacitor the wider the surface of the plate the greater its capacity to store charge because the parallel plate capacitor capacity meets the equation $C = \varepsilon d/A$, with C= capacitor capacity, d=distance between parallel plates, and A=the area of the surface of the parallel plate.
16. In the parallel plate capacitor the greater the distance between the surfaces of plates the greater its capacity to store charge because the parallel plate capacitor capacity meets the equation $C = \varepsilon d/A$, with C= capacitor capacity, d=distance between parallel plates, and A=the area of the surface of the parallel plate.
17. Some capacitors in series circuit, the capacity of the equivalent capacitor is greater than the capacity of each component.
18. In some capacitor with different capacities connected in series, the potential difference of each capacitor is the same.
19. Some capacitors with the same capacity that connected in series, the capacity of the substitutes are greater when they connected in parallel.
20. Energy stored by some capacitors with the same capacity connected in series is greater than the energy stored by some capacitors with the same capacity connected in parallel because the capacity of the substitutes connected in series is greater than the parallel circuit. Energy stored in capacitor $E= ½CV2$.
21. The electric field strength in the center of a ball cell whose inner part radius r and outer part radius R charged +Q distributed evenly in the ball cell is because the electric field strength in a point inversely proportional with the square of the distance of the point to the source charge. Here the students apply electric field formula of the point charge in the continuous charge distribution.
22. A positive charge if placed in an electric field, its potential energy increases because it moves in the opposite direction to the electric field.
23. Electron will move from high potential to low potential.
24. If a positive charge that is released from rest in the uniform electric field, its potential energy will decrease because the charge moves in an opposite direction to the electric field.
25. A positive charge in uniform electric field moves toward low potential, the work done by the negative electrostatic force changes in negative potential energy which means its potential energy becomes lower.
26. The greater the distance between two equipotential surfaces with the same potential difference, the work exerted by the electrostatic force to move the charge from one surface to another becomes greater.
27. The greater the distance between two equipotential surfaces with the same potential, the work exerted by electric field becomes greater, because $E = V.d$, with E = electric field, V =potential different between two equipotential surfaces and d =distances between equipotential surfaces.
28. The wider the surface of the plate of parallel plate capacitor, the greater is the capability to store a charge because $C = \varepsilon Ad$, where C = capacitor capacity, A= area of the surface of the parallel

plate and the d= distance between two parallel plates.

29. If some capacitor is connected in series, the capacity of the equivalent capacitor equals the sum of the capacity of each capacitor. The student regards capacitor series circuit with is the same as electric resistance series circuit.
30. The capacity of the equivalent capacitor of some capacitors that are connected in parallel is smaller than the capacity of the capacitor of each component. The students regard capacitor of the parallel circuit that is the same as are resistance in the parallel circuit.

DISCUSSION AND CONCLUSSION

The high percentage of scientific knowledge about electric current can be assumed to be caused by the fact that before studying at senior high school the students have got a lesson about electric current in their previous education. At junior high school, the students learned the basics of electric charge which included how to make an object become charged, types of charge, and the characteristics of electric charge. However, the percentage of the students who had misconceptions and lake knowledge was still high enough. Meanwhile, the contribution of the percentage of students experiencing misconception on electrostatic force and capacitor was caused by several factors. First, the students did not know that in the interaction between two charges; the students did not know that the electrostatic interaction between two objects with different charges, the two charges experienced the same electrostatic force. On the contrary, the students understood that a greater charge obtains a greater force, even there were also students who understood that a greater charge exerts a greater work toward other objects. This agrees with the finding in Maloney (2001) and Bilal & Erol (2009). It seems that the failure of the students in understanding Newton's third law affects the concepts of the electrostatic force (Meloney, 2001). The students' misconceptions in electrostatic force were also seen from their ignorance of the relation between the distance between two charges, the students did not understand qualitatively that electrostatic force is inversely proportional to the square of the distance between the two charges that interact. A similar misconception is also found by Koudelkova & Dvorak (2015), that the students did not know qualitatively about electrostatic force (Coulomb force). In representing attractive force or repulsive force between two charges in a vector diagram, many students could not differentiate vector length for different attractive force or repulsive force. Similarly, when they were asked to determine the acceleration experienced as the result of an interaction of two objects with the same masses but with different charges, many students said that an object with a smaller charge had a greater acceleration.

The students tried to use Newton's second law in electrostatic force but they thought that an object charge was the same as its mass. For the concept of the capacitor, the students had not learned it at junior high school. The students' misconception about the concept of the capacitor was largely coming from the misinterpretation of series or parallel circuits of some capacitors. At junior high school, the students had learned electric resistance series and parallel circuits. When they were asked about capacitor series and parallel circuits they interpreted them similar to their interpretation of electric resistance series or parallel circuits.

For the concepts that have not been taught at junior high schools such as electric field, electric potential, and the capacitor, many students did not have any knowledge about them (lack knowledge). Electrostatic concepts in general, and electric field, electric potential, and the capacitor, in particular, were less familiar to them in their daily life. Concepts such as electric field, electric line force, the motion of charge in the electric field, an electric field of continuous charge, potential difference, electric potential energy, equipotential surface, the motion of charge in the equipotential surface are abstract concepts that are remote from the students daily life. The students acquire prior knowledge through interactions with their environment. The students' less familiarity with static electricity concepts caused their very low level of interaction with these concepts, this caused a relatively high percentage of the students with lake knowledge about the electric field, electric potential, and capacitor.

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Before entering formal lessons students have had prior knowledge of static electricity concepts. Their prior knowledge can be categorized into four categories: scientific knowledge, misconceptions, lack of concepts, and errors. There are thirty types of misconceptions identified in this study, some of which are alike to those found in misconception literature. Students' prior knowledge of static electricity concepts is very useful in designing appropriate conceptual change strategies. Therefore it is very important for the teacher to identify the variety of student's prior knowledge about static electricity before starting the lesson.

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