Conceptualization Forms of “Electricity, Electric Current and Electrical Energy” by Junior High School (aged 12-14) Students

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Abstract

This study was designed to determine how, after the implementation of the new elementary school Science and Technology Course curriculum, students conceptualized the concepts of *electricity, electric current* and *electrical energy* and how these conceptions changed over time. In the first stage of the study, the curriculum for science and technology in the 4th-8th grades was examined and analyzed. Subsequently, a questionnaire comprising three open-ended questions was administered to a total of 428 6th-, 7th- and 8th-grade (aged 12-14) students. A qualitative analysis of the data determined that although students made a correct conceptualization of “electric current”, they had misconceptions about “electricity” and “electrical energy”.

Keywords: Electricity, electric current, electrical energy, conceptualization.

Resumen

Este estudio fue diseñado para determinar cómo, después de la aplicación del nuevo programa del curso de Ciencia y Tecnología en la escuela primaria, los estudiantes conceptualizan los conceptos de electricidad, corriente eléctrica y energía eléctrica y cómo esas concepciones cambian con el tiempo. En la primera etapa del estudio, fue examinado y analizado el currículo para ciencia y tecnología en los grados 4º-8º. Posteriormente, se aplicó un cuestionario que consta de tres preguntas abiertas a un total de 428 estudiantes de 6º, 7º y 8 º grado (12-14 años de edad). Un análisis cualitativo de los datos determinó que aunque los estudiantes hicieron una conceptualización correcta de "corriente eléctrica", tenían ideas erróneas sobre "electricidad" y "energía eléctrica".

Palabras clave: Electricidad, corriente eléctrica, energía eléctrica, conceptualización.

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I. INTRODUCTION

The subject of electricity is one of the central topics included in all curriculums for primary school grades 4-8. On the other hand, in terms of the cognitive development of students, there is a natural difficulty in learning basic concepts in this subject [1]. Since technologies related to electricity comprise a significant place in daily life, students have some preliminary knowledge and experience on this topic before the period of their formal education and thus base their later learning on this preliminary knowledge and experience [2]. While this is the case, because the terminology used in this field in daily life is far away from a scientific framework, confusion arises about basic related concepts.

The concept of electricity is very closely related to the concepts of electrical current and electrical energy. Although these concepts are conveniently interchangeable in everyday language, from a scientific standpoint, there are specific differences between them. The construction of the process of systematic conceptualization of these concepts is made possible through a systematic and scientific teaching process. One of the greatest obstacles to learning is the existence of misperceptions and misconceptions during the process of transferring concepts from everyday life into the school environment.

“Energy is saved by using less electricity” [3]. This sentence is important in explaining the relationship between electricity and energy. Here, the relationship between the two concepts has been drawn following a correct process of conceptualization. On the other hand, while electricity cannot be stored in large amounts, energy can. This is because the conduction of energy is limited to the type of conduction and the capacity of the particle making the conduction possible. For example, the number and capacity of the charges that allow the transfer of these charges through a conductor is limited. That is why they will not allow the transfer of energy of over a certain amount. When transfer is not possible, however, the energy may be stored in great amounts in matter as internal energy. The energy stored in the atom nucleus and in chemical bonds may be offered as examples of this.

Energy must be the starting point for understanding the concept of electricity. Although the definition of energy is difficult, it is easier and more accurate to conceptualize compared to the other concepts. Energy, which is a concept encountered both in the school and the non-school environment, is created in the presence of a microscopic or macroscopic movement [4]. Whether it is scientific or not, the concept of energy is a central topic. For this reason, energy facilitates the learning of the concept of electricity. That is, in nature, energy cannot be created and destroyed but can only change from one form to another. These transformations take place by heat, light, work, sound and physical wave. In this context, electricity, when the definitions of electric current and electrical energy are considered, is a form of electrical energy (work). Energy is transferred from one place to another in the form of work (electricity). On the other hand, an electric current is the flow that enables work to be conducted in a conductor. This is nothing more than the complete shift of the charge in a conductor from one place to another. Lastly, electrical energy is the total energy of the charges that make energy transfer possible in a conductor [5].

A. Analysis of Previous Research

In connection with *electricity*, the students have a basic knowledge and idea that electricity was made up of electrons and that an electric current comprised electrons moving in the same direction [6]. In addition, students base their mental models on the following knowledge: (1) Distinguishing words that are connected to electricity in everyday language, (2) Conservation of current, (3) The nature of an electrical current [7].

An examination of the literature shows that there are different studies that have examined and analyzed how students understand the concept of electric circuits [8, 9], how modeling facilitates the teaching of concept of electricity [7, 10], and how students master the concept of electricity and which ideas they have about the concept [1, 11]. Students think of electric current as a flow of energy [7, 12], a flow of electrons [13] and as something particles in movement [14]. As concerns the production of a current, students think that an electric current is produced by atoms leaving protons inside a metal [15], that a battery is the source of a current [2, 7, 12, 16], that a current is produced by atoms in elements being electrical conductors, that a current is not a moving phenomenon and that only an atom can take on an electric charge [17]. In addition, many students confuse the qualities of current and energy [18], and concepts of electricity and current [19].

B. Curriculum Context

In order to analyze the existing conceptualizations in their minds, it is important to know which facts students encounter in the different stages of their basic education. In this context, the concepts of "electricity", "current" and "electrical energy" included in elementary school programs and textbooks have been examined for grades 4-8.

In the 4th grade curriculum, the terms "electricity" and "electrical energy" have been used synonymously in different places: *[(Students)…will reach an awareness about how electricity, which is a type of energy, is consumed.], [At the end of this unit, students will understand the impact of the use of electrical energy on society; (they)…will learn the that electricity must be used consciously at home, at school, in the village, in the city.]* (p. 139). Also included in this grade's curriculum is the statement, *"(they)…will understand that electricity is a kind of energy" (p*. 139). The movement of electricity is described as followed in the textbook: "*Electricity passes through wires. …the force that makes electricity pass through wires is obtained from electrical sources"* [20: p. 198].

In the 5th grade curriculum, the concept of electricity has been expanded on the basis of simple circuit applications. The dangers of electricity and needed measures are treated here. In addition to this, the concept of energy has been handled in connection with solar and heating energy as well as with combustion.

In the 6th grade curriculum, subjects related to electricity have been centralized as "electrical energy". In addition, there is also some instruction about safety: "*lists of precautions to be taken to ensure personal safety and the safety of others to prevent electric shock"* [20: p. 132].

In the 7th grade curriculum, an introduction is made for the first time to "electric current" and "electric charges." The instruction in the curriculum is as follows: (1) *Electric charges are identified as positive (+) and negative (-). (2) It is taught that alike electrical charges repel each other while opposite electrical charges attract.* (3) *It is taught that in induction, objects exchange negative charges, leading to positive or negative overload (imbalance of charges. The 7th-grade textbook explains this in this way: "Scientists name these electric charges positive charges (+) and negative charges (-). In short, it can be said that glass and other masses like glass are something charged masses whereas ebonite and masses that act like ebonite bars are negatively charged masses." "Masses whose positive and negative charges are equal are called neutral masses."* [20: p. 105]. Furthermore, the concept of electric current is defined as, *"The energy transfer arising from the vibrating movement of negative charges is called an electric current."* [20: p. 113].

In the 8th grade, the subject of electricity has been taken up more detailed under the heading of "how magnetism affects our lives." The new topics (new instruction) in this unit include *the production of electrical energy, its transfer and distribution*. Added to this is the subject of energy conservation. This unit treating the creation of electricity and its effects is on the highest conceptual level. Together with magnetism, created by the effect of an electric current, these two topics are among the most important topics of physics and form the basis of the subject of electromagnetism (MEB). Finally, the unit emphasizes the importance of the relationship between energy and life, expressing this as, *"it is impossible to think of life today without electricity."* [20: p. 158].

C. Theoretical Background: The conceptualization process

Concepts are abstract but "*not totally detached from the concrete" or* "*tied to the concrete"* [21]. They are the patterns of the many qualities of every object that have been fixed and coded in our minds. We can find information about the general characteristics of objects in a concept. This, however, will never be a complete reflection of the object in the mind. A concept is structured after a long process and can only find its true meaning at the end of this process. The long process is nourished by both scientific and non-scientific sources. The qualities of the objects that are a part of this process of creation and development, the whole of the phenomena that have been integrated into our lives and the series of events in which we ourselves take a part provide the sources for the process. There is often confusion between the quality itself (on an objective level) and what it represents (on a mental level) in the case of a concept that has been constructed devoid of scientific content [22]. Searching for the quality in the representation or attributing the quality to the concept is a confusion of the abstract and concrete.

The conceptualization process is a system that is run by mental dynamics. The conceptualization process at the same time is a process of receding from the concrete, retreating from qualities and approaching the abstract (the language of the brain) [23]. This can be thought of as channels of communication that are constantly in interaction with each other. The process begins in the world of objective truths and continues with sensorial, perceptual and cognitive experience. Data which is obtained through this experimental process is subjected to a new mental organization. The "representant" and the "represented" in this process are connected and assigned meaning. In this way, objective truths that have been shaped by experience begin to be represented as meaningful wholes on an intellectual level. Such representations are recorded in the mind in the format of what might be called cognitive software. These take the form of "*conceptualizing*", "*imaginary*" and "*linguishtic wholes*" [22, 24]. This record, however, is more than a recorded photograph but manifests in a *renewing-transforming-producing* format. It is like a computer program that updates itself. It functions within the system, renews itself in the different processes and changes, taking on a different form in the next process and producing something different from what came before.

Objective truths are not only expressed in our minds on a conceptual dimension, the same time, they have imaginary and linguistic dimensions. This, in effect, is an indication that concepts are structured in our minds in the form of a relational network [25]. The first of these indications is that when mention is made of a concept, it is something that calls to mind *a word, a meaning or a piece of the imagination*. The second is that a concept always stands in a system together with other concepts and that otherwise it is a part of a conceptual network [23]. The last is that scientific concepts are only connected with events that take part in creating theories and their components [26, 27].

When the studies in the literature are examined, it can be seen that students in general have difficulty with the concepts of electricity, electrical energy and electric current. Previous studies have pointed to the necessity of determining how students conceptualize these three concepts. On the other hand, it is seen that there are studies of students in the 8-12 and over-16 age groups which have generally been conducted to determine their ideas abouts concept of electricity. In contrast, there are very few studies which have questioned the ideas of students in the 12-14 age groups. Furthermore, although there are many studies having to do with electric current, few studies exist that have questioned students' knowledge about the concepts of electricity and electrical energy. Because of this, the present study has dealt with the conceptions of students, ages 12-14, about these subjects and with the conceptual changes that occur over time.

Our study has been designed to set forth how children in the second tier of elementary education conceptualize *electricity, electric current* and *electrical energy* within the framework of the new science and technology curriculum now implemented in the schools, exploring also how this conceptualization changes over time.

In this context, the research questions of this study are the following:

1. How do students perceive and conceptualize these related concepts? How does this change over time?
2. What mental images about these concepts do students develop in the learning process? How do these change over time?

II. METHOD

The concepts of *electricity, electric current and electrical energy* that are a part of the science and technology curriculum for grades 4-8 were examined in the first stage of the research. Later, a review was made of existing literature related to these concepts. In the next stage, discussions were held with three experienced science and technology teachers and, on the basis of the results of an examination of both the science and technology curriculum and the literature, a test was drawn up consisting of three open-ended questions that would question students' knowledge about the concepts of *electricity, electric current* and *electrical energy*. This type of test is preferred because it provides more information compared to multiple-choice testing [28]. The test was administered as a pilot implementation following the necessary arrangements that were made with two schools in the province of Samsun. The research was carried out on a sampling of a total of 428 subjects made up of 6th grade (n: 163), 7th grade (n: 119) and 8th grade (n: 146) students.

The analysis of the data was performed in the following stages: (1) Student responses were categorized and grouped into sub-categories by the researchers according to common characteristics of expression and main ideas, frequencies and rates were calculated and in addition, continuous comparisons were made for the purpose of finding common categories among students; (2) Data analyzed from the main and sub-themes obtained was supported with direct quotations from student responses. These quotations were written in italics. Such direct quotations strikingly reflect the ideas and experience of the participant [29]. (3) The findings were explained, connections were drawn and interpretations were made by the researchers. Since one student could offer several characteristics at a time, the total characteristics in the tables (see appendix) exceed the number of students. Because of this, the tables have been drawn up to have each response correspond to a different item.

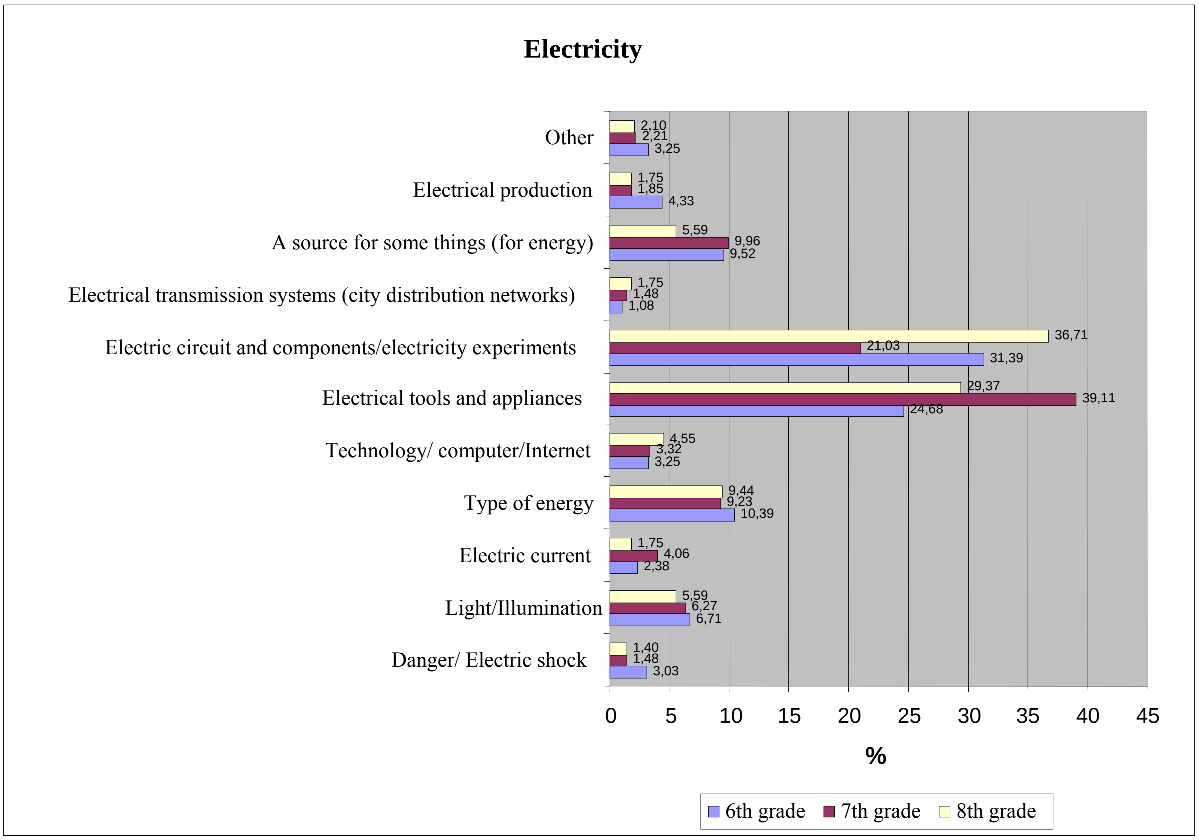
III. RESULTS AND DISCUSSION

The tables showing the categories and sub-categories set up at the conclusion of the analysis of student responses to each question are presented in the appendix.

Electricity

Question 1: What comes to your mind when we say electricity? Please explain.

Chart I. Students' ideas about electricity



The chart I shows the distribution of student ideas about the subject of "electricity." Here, a large portion of the students (6th grade, 25%; 7th grade, 39%; 8th grade, 29%) think of the electrical tools and appliances used in daily life.

About 1/3 of 6th and 8th grade students and 1/5 of 7th grade students think about electric circuits and circuit components when they heard electricity. This may be explained by how an introduction is made into the subject of electricity in these grades by the construction of simple circuits and components.

About 10% of 6th and 7th grade students think of electricity as a source of energy, heat, light and power. In the 8th-grade this rate drops down by half.

About 10% of 6th, 7th and 8th grade students define electricity as a type of energy. Student beliefs in this context are similar to the following: *"It's a type of energy that we use to make our lives easier"*, *"Electricity is a type of energy that can be transformed into heat and light." "It's the energy produced by electrons that touch each other."* In addition, even if only few in number, it was striking that some students defined electricity as a "unit of energy."

Six percent of the students in all three classes tried to explain electricity in terms of light and illumination: *"Electricity has many effects on our life. If we didn't have electricity, people's lives would be much different, that is, if we didn't have electricity, people would be burning kerosene lamps and candles."*

Some students defined electricity as power and force: *"Electricity is the force required to oppose resistance," "Electricity is the power needed to operate machinery and illuminate light bulbs."*

The distribution seen in the chart I shows that students did not think of the conceptual meaning of electricity and, because they could not quite formulate it in their minds, they perceived it as anything that had the word "electric" attached to it, such as in the examples of electrical appliances, electric shock, electric power plant. It can be said that knowledge about the subject remains in the dimension of perception/experience because school programs concentrate more on electric circuits/circuit components and electrical appliances.

Electric current

Question 2: What comes to your mind when we say electric current? Please explain.

Chart II. Students' ideas about electric current.

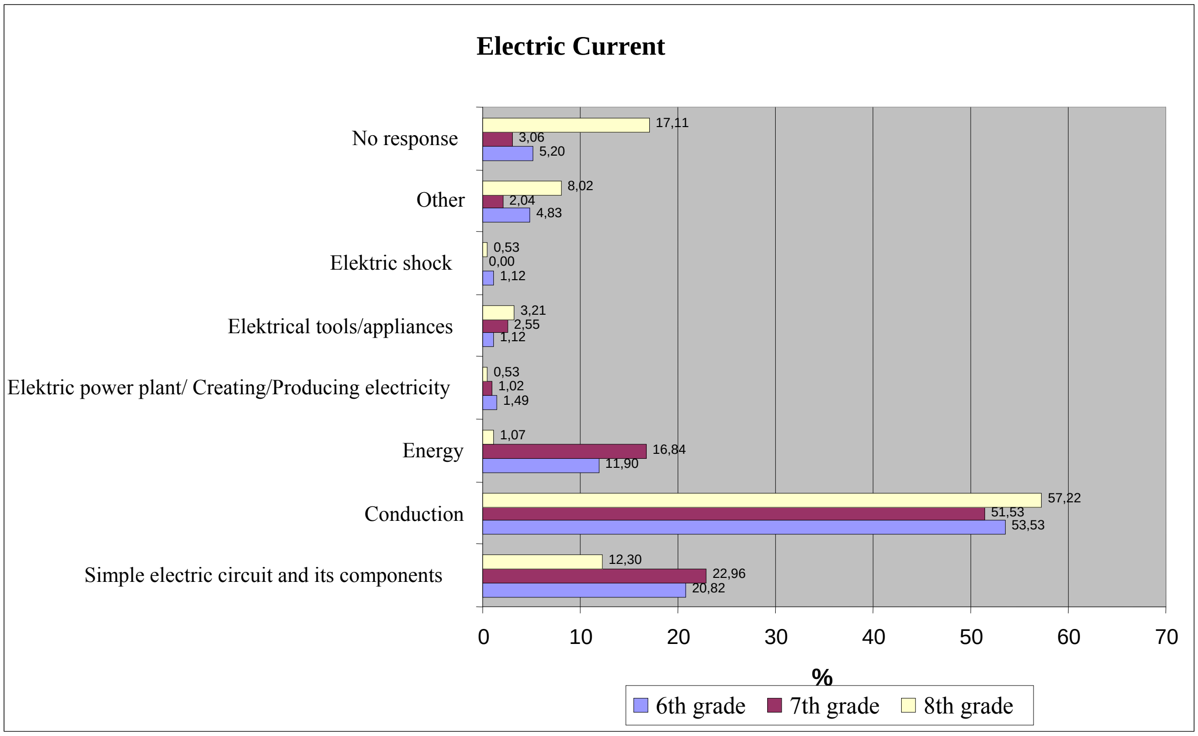


Chart II shows the distribution of students' ideas about the subject of "electric current." According to this chart, more than 50% of the students (54% in the 6th grade, 52.8% in the 7th grade and 58% in the 8th grade) connect electric current with the concept/phenomenon of "conduction." Students explain the subject in this way: "*This is the carrying/transfer/flow/conduction of electricity from one place to another", "Electric current is when electricity flows/moves/is conducted from a positive (+) pole to a negative (-) pole", "This is the regular and continuous flow of electrons over a conductive wire in open circuits."*

In the 6th and 7th grades, 21% and 23%, respectively, of students make the connection between an electric current and a simple electric circuit. In the 8th grade, this rate remains around 12%.

On the other hand, the rates of students connecting electric current with energy is 12.7% in the 6th grade, 17% in the 7th grade, dropping sharply to 1% in the 8th grade. Some students define current as the energy that passes through a conductor: "*It's the energy that passes through cables", "It's the energy that comes from batteries"* Others define it as the conduction of energy through a conductor: "*It's the conduction of electrical energy through cables."* Still others define it as the path followed by electricity/energy: *"It's the path of energy through cables", "it's the path of electricity."*

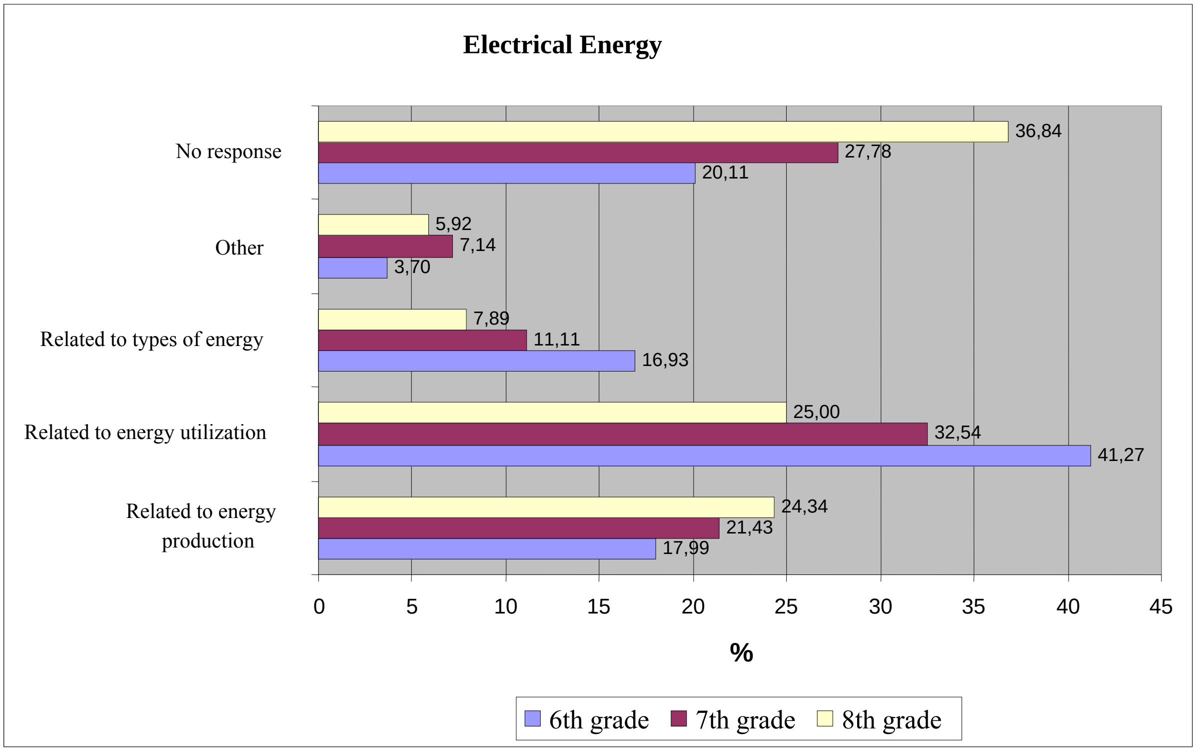
Lastly, experiences with the electrical tools/appliances we are familiar with in daily life (less than 3% in each class), with electrical power plants/creating and producing electricity (less than 2% in each class) and electric shock (less than 1% in each class) have been noted .

This chart shows that more than 50% of the students in each grade were able to connect electric current with the concept/phenomenon of "conduction," thus appearing to be in a stage where they were conceptualizing correctly.

Electrical energy

Question 3: What comes to mind when we say electrical energy? Please explain.

Chart III. Students' conceptions about electrical energy



The chart III shows the distribution of students' ideas about the subject of "electrical energy." We encounter three themes here related to electrical energy. The first of these is related to utilization (42.7% in the 6th grade, 33% in the 7th grade and 25% in the 8th grade; tending to decrease): *"It's the power that is used to light up our homes, streets, etc.","It's the flow of power that operates electrical appliances", "It's the energy that illuminates light bulbs."*

The second theme involves ideas related to production (18% in the 6th grade, 22% in the 7th grade and 24% in the 8th grade; tending to increase). These conceptions are usually that energy is produced in electrical power plants and by dams.

The third theme is what electrical energy is represented by types of energy (17.7% in the 6th grade, 11% in the 7th grade and 8% in the 8th grade; tending to decrease). Some student conceptions are: *"Electrical energy is a type of energy", electrical energy is a type of energy that can be transformed into heat energy."* On the other hand, the rates of students who did not offer a response to the question on electrical energy showed a gradual increase upwards from the 6th to the 8th grades (20%, 28%, 37%). The tendency of distribution in the chart is toward making a connection with production, utilization or type for electrical energy, with no tendency in any other direction. It can thus be seen that the conceptualization process related to electrical energy, although clustered, is still incomplete.

VI. CONCLUSIONS

Many subjects in the Science and Technology course are either directly or indirectly connected with energy. It is for this reason that energy is the central point of the sciences. Energy cannot be created and destroyed but may be transformed from one form into another. This transformation occurs with heat, light or work. Electricity takes its place on the lower rung of work. In other words, energy is transferred from one form to another through work. For example, the chemical energy inside a conductive wire found in a battery on an electric circuit can turn an electric motor by performing work that is produced through the "*Vibrating movement of negative charges…"* [20: p. 113]. That is, the chemical energy found in the battery is transferred to the motor as energy of movement through work. This is why curriculums should treat the subject of teaching these concepts in the following order: energy, energy sources, forms of energy, passage/transfer of energy from one form to another (heat, light, work (mechanical, electrical, etc.)), electricity, how conduction creates electrical work (current) and the energy that makes this energy possible (electrical energy). This would mean that the concepts of electricity, electric current and electrical energy would be treated under the umbrella of energy. Should these subjects be treated under electricity or electrical energy, as in present curriculums [30], it will be inevitable that there will be conceptual confusion and as a result, the conceptualization process will remain incomplete or deficient.

An examination of the Elementary School Science and Technology curriculum shows that since electricity is treated as "a type of energy" only in the 4th grade, "electrical energy" is treated only in the 6th grade while electric current is identified in the 4th grade as "something that flows through wires", as "the movement/interaction of charges" in the 7th grade and as "movement of charges, electric current and the concept of magnetic fields which are formed because of this" in the 8th grade, it may be said that the process of correct conceptualization of this subject is in progress. Because from the 4th grade to the 8th grade, science and technology programs do not treat the nature of electricity and the concept of electrical energy in a systematic and gradual progression, it is seen that students' ideas and their conceptualization process regarding these subjects are as yet incomplete. When analyzed according to the expectations foreseen by the curriculum, it is apparent that students do not reach desired levels of learning.

The most significant conclusion to be drawn from this study is that curriculums that do not offer the opportunity to correctly conceptualize topics lead students into knowledge deficiency or inaccuracy. This is one of the primary reasons behind misconceptions. An important portion of the misconceptions encountered in students' responses may be said to originate from curriculums that do not allow conceptualization or that do not treat subjects in a systematic manner within the curriculum.

Lastly, when a 4th-year student in Science Education Department [3] is asked about the relationship between electricity and energy, the explanation *"Energy is saved by using less energy (performing less work)"* is significant in that it shows that when the right conceptualization has been achieved, it appears that the relationship between electricity and energy is not difficult to understand.

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APPENDIX

Table I. Data obtained from the responses of students to the question regarding electricity.

Definitions			**6th grade**		**7th grade**		**8th grade**	
			No: 163	**%**	**No: 119**	**%**	**No:146**	**%**
Danger/ Electric shock			14	9	4	3	4	3
Light/Illumination			31	19	17	14	16	11
Current			11	7	11	9	5	3
Type of Energy			48	29	25	21	27	18
Technology/ computer/Internet			15	9	9	8	13	9
Experiments related to Physics/Electricity			1	1	-		1	1
Electric tools and appliance	Only "Electric/electronic appliances/equipment/machines"		39	24	38	32	32	22
	Together with electronic equipment		45	28	40	34	41	28
	Other	Electric stove	1	1	2	2	1	1
		Washing machine	3	2	4	3	-	
		Dishwasher	2	1	3	3	1	1
		Refrigerator	4	2	6	5	1	1
		Vaccum cleaner	5	3	-		2	1
		TV	13	8	10	8	5	3
		Iron	2	1	3	3	1	1
		Total	**30**	**18**	**28**	**24**	**11**	**8**
Electric Circuits	**Simple electric circuit and components**	Only "Electric circuit"	9	6	1	1	3	2
		Together with circuit components	45	28	37	31	34	23
	Circuit components	Lamp, amplifier, florescent light	40	25	13	11	32	22
		Cables, copper wires	16	210	1	1	3	2
		wall sockets	3	2	4	3	4	3
		Key	9	6	-		5	3
		Battery	14	9	1	1	2	1
		conductors, non-conductors	7	4	-	-	-	-
		Light socket	1	1	-	-	-	-
		Rheostat	-	-	-	-	4	3
		Generator	-	-	-	-	4	3
		Ampermeter	-	-	-	-	5	3
		Voltmeter	-	-	-	-	4	3
		Series and parallel connections	-	-	-	-	4	3
		Total	**90**	**55**	**18**	**15**	**67**	**46**
Electricity transmission systems	**City networks**	Electric poles	3	2	3	3	-	-
		Elektric wires	1	1	-		-	-
		Street (city) lamps	1	1	1	1	2	1
		Transformer station	-		-		3	**2**
		Total	**5**	**3**	**4**	**3**	**5**	**3**
Different Sources (energy)	Energy source		3	2	4	3	-	
	Heat source		10	6	4	3	3	2
	Light source		30	18	12	10	4	3
	Power source		1	1	4	3	5	3
	Resistence source		-		3	3	4	3
	Total		**44**	**27**	**27**	**23**	**16**	**11**
Electricity roduc-tion	Dams		9	6	2	2	5	3
	Energy/Electric power plants		11	7	3	3	-	
	Total		**20**	**12**	**5**	**4**	**5**	3

Other	Edison/Bell	5	3	-	-	-	-
	Rain	1	1	-	-	-	-
	Lightning	4	2	1	1	-	-
	Unit of energy	-		2	2	4	3
	Movement	1	1	1	1	-	-
	Negative charges/electrons	-		1	1	1	1
	Water	3	2	1	1	-	-
	Sun	1	1	-	-	-	-
	Static electricity	-		-	-	1	**1**
	Total	**15**	**9**	**6**	**5**	**6**	**4**

TABLE II. Data obtained from the responses of students to the question regarding electric current.

		6th		**7the**		**8th**	
		N	**%**	**N**	**%**	**N**	**%**
Simple electric circuit and components	Electric circuit	5	**3**	7	**6**	1	**1**
	Cable	17	**10**	7	**6**	3	**2**
	Conductor	9	**6**	-		-	
	Switch	6	**4**	3	**3**	-	
	Battery	4	**2**	6	**5**	3	**2**
	Non-conductor	4	**2**	-		-	
	Light bulb	3	**2**	5	**4**	1	**1**
	Resistance	2	**1**	3	**3**	4	**3**
	Battery bearing	1	**1**	-		-	**-**
	Light socket	1	**1**	2	**2**	-	**-**
	Electrical outlet	1	**1**	-		-	**-**
	Voltmeter	2	**1**	1	**1**	-	**-**
	Ampermeter/measuring with ampermeter	1	**1**	11	**9**	11	**8**
	Total	**56**	**34**	**45**	**38**	**23**	**16**
Conduction	The movement/flow/transmission of electricity through a cable	70	**43**	56	**47**	45	**31**
	Transmission of electricity from one place to another	42	**26**	17	**14**	25	**17**
	Electricity reaching a light bulb and lighting it	26	**16**	19	**16**	32	**22**
	Diffusion/distribution	3	**2**	-		1	**1**
	Method	3	**2**	9	**8**	4	**3**
	Total	**144**	**88**	**101**	**85**	**107**	**73**
Energy		32	**20**	33	**28**	2	**1**
Electric power plant/production/creation of electricity		4	**2**	2	**2**	1	**1**
Electrical tools/appliances		3	**2**	5	**4**	6	**4**
Electric shock		3	**2**	-		1	**1**
Other		13	**8**	4	**3**	15	**10**
No response		**14**	**9**	**6**	**5**	**32**	**22**

Table III. Data obtained from the responses of students to the question regarding electrical energy.

		6th grade		7th grade		8th grade	
		N	%	N	%	N	%
Related to energy production	Produced by a battery	7	**4**	6	**5**	2	**1**
	Energy production	4	**2**	4	**3**	5	**3**
	Electric power plants and damsa üretilmesi.	23	**14**	17	**14**	20	**14**
	Production through chemical means	-	-	-	-	2	**1**
	Production of energy through its rapid	-	-	-	-	3	**2**
	Producing energy with the kinetic energy of	-	-	-	-	2	**1**
	Transformer station, electric pole, generator	-	-	-	-	3	**2**
	Total	**34**	**21**	**27**	**23**	**37**	**25**
Related to energy utilization	Power	11	**7**	6	**5**	2	**1**
	Resistance	8	**5**	-		-	
	The energy necessary to light a light-bulb	30	**18**	19	**16**	21	**14**
	The energy necessary to work electrical appliances	29	**18**	16	**13**	15	**10**
	Total	**78**	**48**	**41**	**34**	**38**	**26**
Related to Types of Energy	Its being a type of energy	16	**10**	11	**9**	4	**3**
	Solar energy	3	**2**	-	-	-	
	Potential energy	-		-	-	1	**1**
	Electrical energy	4	**2**	-	-	3	**2**
	Wind energy	1	**1**	-	-	1	**1**
	Kinetic, potential and magnetic energy	-		2	**2**	-	-
	Transformation into another type (heat) of energy	8	**5**	1	**1**	3	**2**
	Total	**32**	**20**	**14**	**12**	**12**	**8**
Other		**7**	**4**	**9**	**8**	**9**	**6**
No response		**38**	**23**	**35**	**29**	**56**	**38**