

**INFLUENCE OF MOTHER TONGUE (CHOPE)
ON
TEACHING AND LEARNING
IN SCIENCE EDUCATION:
A MOZAMBICAN STUDY
ABOUT
FUNDAMENTAL ELECTRICAL CONCEPTS**

by

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**A RESEARCH REPORT
in partial fulfilment of the requirements
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ABSTRACT

This research report investigates the influence of Chope (a native Mozambican language) on the teaching and learning of fundamental electric concepts.

Two research instruments were used: a written task and an interview. The written task investigated students' understanding, in Chope and Portuguese (the instructional language), of twenty fundamental electric concepts, as well as translations of scientific sentences about electricity from Portuguese to Chope. The interview was used as an auxiliary instrument to better understand procedures used in the written task.

The study showed that Chope as prior knowledge can be understood in three ways: (1) as a positive influence when knowledge acquired through Chope is scientifically acceptable; (2) as a negative influence when a Chope "definition" hinders understanding of an electric concept; and (3) as an auxiliary agent in the understanding of the precise meanings of electrical terms. There are however other influences such as childhood environment and common usage.

DECLARATION

I declare that this research report, submitted for the degree of Master of Science in Science Education of the University of the Witwatersrand, has not been submitted to any other university. I declare that the empirical investigation, data processing and interpretation of results are my own unaided work. I however acknowledge the considerable assistance obtained with literary style and presentation.

Aguiar M. Baquete

Aguiar Muambalane Baquete
20/03/1998

DEDICATION

To my wife
Judite Ernesto Muxlhanga (MAJU)
and to
All BAQUETES' FAMILY

who sacrificed many hours of their comfort in order that I fulfil the challenges of this academic degree. A special hug for my parents, **Fernando Baquete & Florentina Sechene.**

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A great NIMONGUTTE KA VOTHSE BVA MANDALENE NI BVA INPFULUENE KALAKUPENDUKA.

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- Section 4.3 - Basic concepts of DC circuits
- Section 4.4 - Circuit components and instruments

LIST OF TWENTY (20) ELECTRICAL TERMS THAT WILL BE USED DURING THIS RESEARCH

01. Load (Carga)	(11)
02. Electric field (Campo eléctrico)	(07)
03. Electric charge (Carga eléctrica)	(13)
04. Electricity (Electricidade)	(19)
05. Work (Trabalho)	(20)
06. Energy (Energia)	(01)
07. Potential difference (Diferença de potencial)	(16)
08. Electric current (Corrente eléctrica)	(12)
09. Electric power (Potência eléctrica)	(08)
10. (Electric) current intensity (Intensidade da corrente (eléctrica))	(04)
11. Conventional current (Corrente convencional)	(09)
12. An insulator (Um isolador)	(06)
13. A parallel electric circuit (Circuito eléctrico em paralelo)	(14)
14. A source of electromotive force (EMF) (Uma fonte da força electromotriz (FEM))	(17)
15. Electrical resistance (Resistência eléctrica)	(03)
16. A battery (Uma bateria)	(18)
17. (Metal) wire (Fio (metálico))	(15)
18. A switch ("interrupter") (Um interruptor)	(05)
19. Voltmeter (Voltmetro)	(02)
20. An electric circuit (Um circuito eléctrico)	(10)

N.B.: The numbers in brackets indicate the randomised order on the questionnaire.

CHAPTER 1

ORIENTATIVE INTRODUCTION

1.1. BACKGROUND TO THE STUDY

1.1.1. Learning problems with fundamental electric concepts

The nature of scientific subjects is such that acquired knowledge predetermines subsequent knowledge (Law, 1993). If acquired knowledge is well accommodated into the cognitive structure of learners, they will have a better opportunity to attain a desirable level of understanding of new concepts within a specific scientific topic. According to Shipstone (1985), an understanding of current in simple electric circuits is a prerequisite to a better understanding of other topics like series and parallel circuits, electric potential and electric energy. Cohen, Eylon & Ganiel (1983) claimed that potential difference and current are the keys to understanding electric circuits.

It has been observed in many studies on electricity (e.g. Cohen, Eylon & Ganiel, 1983; Solomon et al., 1985; Shipstone, 1985) that many students have difficulty in understanding fundamental electric concepts such as current, resistance, potential difference and power.

A major source of students' difficulties in understanding science, including fundamental electric concepts is the language through which the instruction is carried out (e.g. Strevens, 1980a; Widdowson, 1984b). Other researchers claim that the problem is that students do not understand the precise meaning of various terms used in science (Sanders & Nhlapho, 1993).

This study looks at the role of the mother tongue in the teaching and learning of fundamental electric concepts. The mother tongue is the language that the child speaks at home. It is also called the mother language or the home language (Rollnick & Manyatsi, 1997). The mother tongue being investigated in this research is CHOPE, one of many native languages spoken in Mozambique, a former Portuguese colony in Southern Africa.

1.1.2. Situation in Mozambique

Since 1975, when Mozambique attained independence, the government has made considerable efforts to improve the educational system, overall and in the sciences in particular. An important objective was to upgrade the understanding of mathematics and scientific subjects among teachers and students. Some examples of these efforts are:

- The creation of the Instituto Nacional de Desenvolvimento de Educação-(INDE) (National Institute for Educational Development).
- The introduction of the Sistema Nacional de Educação-(SNE) (National Educational System). All levels of the SNE from primary school up to Standard 12 have textbooks written in Portuguese. Although there are still insufficient textbooks for every student, they are nevertheless important instruments in all Mozambican schools.

N.B. In the SNE for physics, studies in electricity have been introduced at different levels in the elementary school. Prior to independence the topic was introduced only at Standard 9, the equivalent of the present Standard 10 of the SNE.

- The Basic University Science Course Experimental Project (BUSCEP) is an educational project that has been running since 1985. This project involves the University Eduardo Mondlane (UEM) in Maputo and the Vrije Universiteit Amsterdam (VUA) in the Netherlands. Since 1992, BUSCEP has had the status of a department within the Faculty of Science at UEM.

Pedagogically, BUSCEP is a foundation course. At present it is compulsory for all first semester undergraduate students in the Faculty of Science. The purpose of the BUSCEP course is to upgrade the level of students' qualitative knowledge in physics, chemistry, biological science and mathematics, and to improve students' skills such as instrument manipulation in the laboratory. The intention is to provide a solid foundation for undergraduate students in order to support major courses in the Faculty of Science.

Another important objective of BUSCEP is to train Mozambican staff to participate in mathematics and science education research. A reason for doing this study was our intention to start these kinds of studies in Mozambique, a multi-language country with more than twenty mother tongues.

However, when students enter University, most still show a lack of knowledge about fundamental electric concepts. The researcher's concern is that they continue to lack this knowledge, and also exhibit many alternative concepts, even after attending the BUSCEP course.

1.2. AIM OF THE RESEARCH

This research intends to help science educators and teachers to understand how the native/indigenous Mozambican languages, in particular Chope, affects students' understanding of fundamental electric concepts when they are taught through the medium of Portuguese.

1.3. RESEARCH QUESTIONS

Does Chope have any influence on BUSCEP physics students, who are native Chope speakers, in understanding the precise meaning of:

1. ordinary words often used in the instructional language (Portuguese)?
2. physics terms used during teaching and learning the section on electricity in the BUSCEP course?

SUB-QUESTIONS

- a. Are there relationships between Portuguese and Chope when students are talking about fundamental electric concepts?
- b. What scientific words are new or unusual in the vocabulary of native Chope speakers (BUSCEP Chope students)?
- c. What procedures do students adopt when they translate scientific sentences related with fundamental electric concepts from Portuguese to Chope?
- d. How do students talk about fundamental electric concepts in Chope?

- e. *What are students' attitudes to language when they find words not translatable in Chope?*

1.4. DESIGN AND METHODOLOGY

1.4.1. Population and sample

For this study, the sample was the twenty-eight BUSCEP Chope speaking students of 1997. BUSCEP students come from all over Mozambique. They were around three hundred (300) in number, of both genders. All study Physics.

Chope is the researcher's mother tongue, although he speaks other Mozambican languages (e.g. Changane and Ronga) and is proficient in Portuguese (the instructional language).

As the study is confined to Chope, with Portuguese as the instructional language, we will not attempt to claim generalizability of results across the whole of Mozambique.

1.4.2. Instruments

There are many methods for collecting information about students' knowledge and understanding. We used the following instruments:

- A written paper-and-pencil test, in the form of a questionnaire. This was completed by all BUSCEP students.
- An individual semi-structured interview for some Chope students only.

The data was collected between 28 October and 16 November, 1997.

1.5. DATA ANALYSIS

The data generated by this research came from the written task (questionnaire), with interviews as an adjunct. The data was analyzed to reveal how students understand fundamental electric concepts in Portuguese and Chope.

Other data from the interviews was obtained in order to get some understanding of auxiliary factors (e.g. everyday language, childhood environment, teachers' strategies, textbooks) that could interfere with the learning of electric concepts among Chope students.

The data acquisition, analysis and interpretation are discussed in detail in Chapters 3,4 and 5.

1.6. SIGNIFICANCE OF THE STUDY

1.6.1. At present

This study should provide some understanding of Chope in the teaching and learning of Physics, with specific emphasis on fundamental electric concepts. As a case study it should be helpful for Mozambican science educators to know the relationship between the instructional language (Portuguese) and the mother tongue (e.g. Chope), and between "scientific" language and any "ordinary" language (in this case both Chope and Portuguese).

1.6.2. In future

This research could help Mozambican teachers understand the importance of the mother tongue in the teaching and learning of fundamental electric concepts.

1.7. LIMITATIONS

As with all studies in science education this study has its limitations, such as:

- The study was restricted only to BUSCEP Chope students.
- The study looked only at the language used during the teaching and learning of fundamental electric concepts.
- The study does not include other undergraduate students of the Faculty of Science at UEN, or students from other Universities in Mozambique (e.g. the Pedagogical University in Maputo); conclusions cannot be extended to the whole country, i.e. to all Mozambican undergraduate students.

1.8. PRECAUTIONS AND VALIDITY OF THE INSTRUMENTS

The researcher has more than ten years teaching experience in Physics at different levels, and has taught Physics to BUSCEP students for two years. He has a sound knowledge about the level of Physics content taught within the BUSCEP course. The researcher considers it possible to design suitable questionnaire items to effectively assess BUSCEP students' ideas about fundamental electric concepts. Nevertheless, Physics staff of BUSCEP were asked to cooperate, giving their opinion about the

written paper-and-pencil task, and about the aids for the interview. Their cooperation is very important for the general validity (including content validity) of the instruments. According to Salvia and Ysseldyke (1988: 152) "validity refers to the extent to which a test measures what its authors or users claim it measures". BUSCEP Physics staff know the academic performance of BUSCEP students, and so their comments helped the researcher to draw up a better instrument to extract the information necessary for this study.

To obtain a valid instrument for the written task, the researcher went through the following procedures:

1. He produced a preliminary draft in English, and asked a Physicist and English-speaking person to check the meaning of the scientific words and phrases in the task. The researcher made various necessary and suggested modifications to produce an English 1st version draft.
2. The researcher then translated the questionnaire from English to Portuguese to produce a Portuguese 1st version draft.
3. The researcher asked a Portuguese-English speaking person to translate the questionnaire from Portuguese to English - a so-called "back translation" - to obtain an English 2nd version draft.
4. Comparisons were made between the two English drafts to produce the final English draft.
5. Modifications then had to be made to the Portuguese translation, and the researcher asked a Portuguese-English language expert to validate this translation. This was the final Portuguese research instrument.

This procedure of multiple translations to ensure content validity of translations follows procedures outlined by Singleton, Straits & Straits (1993a).

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

This study intends to research the influence of Chope in the learning of science (which is taught in Portuguese) among Chope speakers. In our investigation of first year undergraduate students we view language as a vehicle of communication that has been developed in the family and at primary and secondary school. Thus the following topics are appropriate for review in this chapter:

1. The importance of language in education;
2. Different types of language used in education;
3. Scientific language as an acquired or learned language;
4. The role of the mother tongue in concept acquisition in the science classroom;
5. The role of previous knowledge in the development of misconceptions in science.

The focus is whether the mother tongue (Chope) might help science students to learn science and develop good communication in science classes, or not. It is important to understand the relationship between the language used in the school environment, and the knowledge conveyed by the teacher through the language used during the teaching process.

2.2. IMPORTANCE OF LANGUAGE IN EDUCATION

One of the main instruments in education¹ is language². Through language people communicate with each other, and so can unlock the capacity to know the feelings and thoughts of others.

-
1. Education is a system of training and instruction, planned for children and/or young people in schools and colleges, and intended to give knowledge, skills and development of character and mental powers (Van Schalkwyk, 1993).
 2. Language is a system of sounds, words, patterns, signs and gestures used by humans to communicate thoughts and feelings (Graddol, Cheshire & Swann, 1994).

Communication can be through talking, reading, writing and using signs (Lemke, 1989). It is inconceivable that people could have constructed their complex social structure without spoken and written language or signals of one kind or another.

According to Ryan (1985), Malamah-Thomas (1987) and Trowbridge & Bybee (1990), communication in the classroom implies interaction through language between teacher and student. It is very important that there is an effective interaction between those who transmit the message, and those who receive it.

Much research has been done on the importance of language in education. Language is a crucial factor in education (Stubbs, 1983; Christie, 1985; Kress, 1989). However there is no general agreement on issues like:

- Is students' language related to learning?
- Is students' language related to success or failure at school?
- What kind of language do teachers and students use in the classroom (in particular the science classroom)?

Educational experts would like to get answers to these socially important questions. Considerable research has been done in areas related to:

- language strategies in the classroom (e.g. Rollnick & Rutherford, 1996);
- students' language (e.g. Stubbs, 1983);
- language between teachers and students (e.g. Malamah-Thomas, 1987; Christie, 1989; Kress, 1989; Trowbridge & Bybee, 1990).

According to Malamah-Thomas (1987) it is impossible to separate language from methodology in the classroom. Language is the primary resource for social communication, while methodology is the source of pedagogic communication.

2.3. DIFFERENT TYPES OF LANGUAGE USED IN EDUCATION

2.3.1. Language in the classroom

Problems relating to language in science classes have concerned many science educators. They would like to know:

- How is the language used in the ordinary classroom

different from that used in the science classroom?

- How can we differentiate between the language used in the physics classroom and the language used in other non-science classes?

According to Strevens (1980) and Rollnick & Rutherford (1996), language is observable. All instances where a teacher and students talk in the classroom can be recorded and then transcribed. This information (data) can be categorised and analysed. These procedures should enable one to know which language is used in a particular classroom.

To know what language is used by teachers or students is very important, because the classroom is a pervasive language environment. Flanders (1970, quoted by Stubbs, 1983) claims that in an informal chalk-and-talk class the teacher tends to talk, on average, 70% of the time. Teaching and learning in the classroom, as we know it, is almost inconceivable without language. Teaching and learning comprise strong language interactions through lecturing, explaining, listening, discussing, etc. Some researchers (e.g. Stubbs, 1983) claim that every teacher is an instructional language teacher.

This is supported by Hadfield (1992), who claims that a physics teacher may have difficulty separating the teaching of physics concepts from the assessment of students' performance in the instructional language. Only in this way can science teachers teach students how to:

- use appropriate terminology;
- give coherent arguments, or to read and understand textbooks.

2.3.2. Features of language in the classroom

To Lemke (1989), teaching and learning procedures in the classroom are a more complex process than merely transferring knowledge. As noted earlier, teaching and learning comprises an interaction between teacher and students through lecturing, explaining, listening, discussing, observations and demonstrations. Therefore teachers and students should be sharing and negotiating ways of talking to each other. Looking at language as an instrument of teaching, Stubbs (1983) warns

that teachers must not expect a students' performance in science subjects (e.g. physics) to be the same as in an instructional language (e.g. Portuguese). The reason is not that the subject matter is different, but that the language style is quite different. In a scientific subject it is common to use one technical term (concept) to explain another term. For example, in the topic of electricity teachers often explain the concept of potential difference through the concepts of energy, work and electric potential.

Stubbs (1983, quoting Kaddie, 1971) asserts that some science teachers are unable to recognise a students' valid idea if it is not expressed in the style and scientific terminology that is used in their specific subject. Some experts (e.g. Widdowson, 1979; Ryan, 1985; Sanders & Nhlapho, 1993) are of the opinion that the language used in science is not the same as the language used in literature or instructional language. There exists, for example, the so called "technological English (language)", the "English (language) for specific proposal", etc. Scientific language often uses words that have Latin or Greek roots (Widdowson, 1979; Strevens, 1980). However, in "technological language" the meaning of words can change in a specific context. For example, the meaning of the word "base" in chemistry is different from the meaning of the same word in everyday language. The meaning of the word "cell" in electricity is not the same as in cytology. The interpretation of concepts like "work", "energy" and "force" in everyday language is different from the interpretation in physics classes. This difference of meanings in a specific context develops the so called paradoxical jargon³ (Sanders & Nhlapho, 1993).

To Krashen & Terrell (1983), it is important not to confuse what a student says with how it is said, especially when the student is still beginning to learn the science subject.

3. Paradoxical Jargon refers to words with more than one meaning, one often being non-technical and the other technical. Even technical meanings of a word may change with the context.

2.4. SCIENTIFIC LANGUAGE AS AN ACQUIRED LANGUAGE

One of the main concerns of science teachers is:

- * How do students acquire or learn the "new" words or scientific terms?

A great deal of research relating to language learning states that language learning is different from language acquisition. According to Krashen & Terrell (1983) language learning is a conscious action. Learning a language includes learning the grammar and knowing the rules of the language. However language acquisition is the development of the ability to use the language in ordinary/informal situations. Consequently, all of us acquired our first language but we also learned the instructional language (which may be a second or third language).

Some of the older studies on children's language (e.g. those of B. F. Skinner) were dominated by the behaviourist approach to language learning. The main point in this theory is that language is an aspect of human behaviour. Like any other forms of human behaviour it is learnt by a process of habit-formation.

Chomsky's linguistic theories and cognitive psychology challenged behaviourist theories. To Chomsky, the learner of a language must not only repeat the new words that he is learning but must internalize the underlying system of rules. The knowledge of these rules governs his linguistic competence. Competence in language is the abstract knowledge of the rules, which is different from the performance that is measurable knowledge.

However, both Chomsky's and Skinner's theories highlight that during the acquisition of the first language or the learning of the second language, the main components are:

- the imitation of sounds,
- the attempt by the learner to be in harmony with the teacher in reinforcing the new sounds learned.

There are many researches related to scientific language acquisition. According to some researchers (e.g. Strevens, 1980; Krishna & Terrell, 1983; Widdowson, 1984; Seddon & Waweru, 1987; Littlewood, 1994) scientific language is a second or third language for students. Therefore learning a scientific language

has the same features as any second or third language learning and/or acquisition. To Littlewood (1994) language is a means of communication. Thus the science teacher should explain the function and importance of scientific language in the specific scientific subject. This procedure could be a contributing factor towards motivating students to learn scientific language. Some functions of scientific language that science teachers can refer to are:

- * Functional needs. Whoever transmits the message desires that the words convey the message without being misunderstood and that the transaction or instruction is carried out efficiently.
- * Social needs. This is where the language has an identity. Whoever knows the language would like to use it in a specific subject or social group.

Some researchers (e.g. Krashen, 1981; Krashen & Terrell, 1983; Littlewood, 1994; Graddol, Cheshire & Swann, 1994) emphasize that language acquisition is responsible for the ability to understand and speak the second language easily and well. In natural conversation the speaking tends to be quite rapid, and attention focuses on what is said, not how it is said. In addition Christie (1985) is of the opinion that knowledge of grammar covers only a small part of the rules.

According to Christie (1985) conscious learning can be helpful in formal situations like examinations, official letters, conferences, etc. Contrasting Christie's opinion with those of other researchers such as Krashen & Terrell (1983), Widdowson (1984) and Littlewood (1994) we conclude that, although learning a scientific language has the same features as learning any second or third language, it is generally only used in formal situations.

2.5. ROLE OF MOTHER TONGUE IN CONCEPT ACQUISITION

This research is designed to research the role of language as a vehicle of communication during teaching and learning certain electric terms. There are agreements among physics educators (e.g. Cohen, Eylon & Ganiel, 1983) and other educational experts

(e.g. Krashen & Terrell, 1983; Poynton, 1982; Trowbridge & Bybee, 1990), that the teaching and learning of any concepts (in particular electric concepts) are complex processes which involve the previous knowledge that students have in their cognitive structure. According to Trowbridge & Bybee (1990), psychological research on the process of concept development recognizes that the process of concept development in the classroom involves *inter alia*:

- * The external environment, since knowledge has an exterior origin, and learning is a copy of reality.
- * The growth and development of the internal cognitive structure of the learner,

Therefore concept development is a construction of knowledge which results from an interaction between the internal structure and the environment. According to Fensham, Gunstone & White (1994), teachers should develop more classroom activities among students when teaching new concepts. Teachers should develop discussions about the meaning of certain words and terminologies used in the specific context of the topic under discussion. Teachers should provide activities for students to develop manipulative skills in the use of instruments, and then ask students to explain their procedure, as an exercise in using the newly acquired terms.

To Piaget, the manipulation of objects is essential for the development of the new concept and consequently for the promotion of good learning (Stanton, 1990b). The intellectual structure is not innate, although the process of acquiring a new concept has an innate origin, and the development of the new concept is a continuous and spontaneous construction process.

To Collison (1974), the basis of concept formation is the perception of stimuli, objects or events. Collison emphasises the relationship between language and thought, and language and teaching, because through language we may stimulate the mind, and build a concrete image. Concept acquisition is a construct of the human mind (Stanton, 1990b). The mind is organized around perceptions of objects, events and the environment. In other words, concept acquisition is a personal mental understanding of

a particular phenomenon. Anyone comes across a phenomenon and mentally forms a picture through a wide range of factors such as social life, learning in school or another kinds of interaction with the environment.

Many educationists consider the use of a second language as a medium of instruction as problematic in teaching and learning (e.g. Carroll, 1961; Macnamara, 1966; Ramos, Aguilar & Bayan, 1967; Cooper, 1971; Collison, 1974 & Goh, 1978, all quoted by Ho, 1982). For them learning science requires abilities to read and understand scientific material as well as the ability to communicate science concepts. The stimuli developed by language in the student's mind develops a picture. This picture will remain and will become the model of that particular phenomenon or event. From this, similar pictures of related phenomena develop, aided by stimuli through language. In this way mental pictures become knowledge in regard to these events and phenomena.

Some researchers (e.g. Malherbe, 1964; Lambert & Locker, 1972, also quoted by Ho, 1982) however claim that learning scientific subjects through a second language may be no more detrimental than via the students' first language. Many first languages (especially in developing countries) do not have enough vocabulary to use in the classroom, particularly in the science classroom. Consequently the mother tongue will not develop any "extra" picture in the science learner that could promote good learning in science classes.

According to Gagne (1965, quoted by Ingram 1975) there are eight kinds of learning involved in second language acquisition, *inter alia*:

- Stimulus. A particular stimulus configuration is linked to a particular response, e.g. when a Portuguese speaker learns how to distinguish and identify the vowel sounds in English words such as "person" and "men", or distinguish the words "meet" and "meat", etc.
- Concept learning. Concept learning is concept formation. This involves the process of isolating and extracting a particular feature from a configuration of features that

characterises a total situation according to a particular purpose.

- Principle learning. Principle learning consists in learning relationships between concepts and between other principles. Principles often start with a conditional action if-then.
- Practice. Practice is the central action to all learning. In second language learning practice is needed to link up the correct categorization of a concept and principle learning.

To Dewey (1933, cited by Collison, 1974) the relationship between language and thought is developed in the following way:

Words are the garb or clothing of thought, necessary not for thought but only for conveying it, while the language is not thought. However, language is necessary for thinking as well as for communication.

Psychologists and educators differ in their opinions on how students acquire their knowledge and learn new concepts, and the role of language in this process. To Piaget (quoted by Stanton, 1990b) children's cognitive operations are acquired with maturation and are less influenced by experience. However Ausubel (1968, quoted by Stanton, 1990b) claimed that anyone could learn a given piece of material if learning experiences were properly structured. To West & Fensham (1974) the methodology procedure is very important in teaching and learning. Vygotsky (1962, cited by Collison, 1974) points out that language and thought stem from different but interconnected roots. Children have a pre-linguist phase in the development of thought, and a pre-intellectual phase in the development of language. Education is an opportunity to merge language and thought.

Nonetheless, there is world-wide agreement among science educators that language in science subjects is different from language in ordinary subjects. When learning science, students must not only learn the scientific content, but they must also acquire the language of science or scientific language (Stevens, 1980; Widdowson, 1984), which contains new words and new terminology. Students must learn their proper meanings in the specific context, because in this specific context scientific

language develops specific concepts.

According to Cassels & Johnstone (1978), the means of communication in education is by words, both spoken and written. Teaching is didactic or discursive, but students' understanding of the language used is of prime importance. Science teachers should look at how students understand scientific words and terminology. Only if the teacher teaches the real meaning of each "new" word or scientific term can he develop effective scientific communication with students (Watts & Gilbert, 1983). Teachers help students to build scientific knowledge through language.

Looking at the language issue, Krashen (1981) and Krashen & Terrell (1983) point out that first language knowledge (mother tongue) and the instructional language have a strong influence on subsequent language(s) acquired by the learner, particularly the language of science. Krashen & Terrell refer to this influence as interference. Littlewood (1994), using behaviourist ideas, argues that the first language as previous knowledge influences the second language learning as subsequent knowledge. This influence can either help or hinder the learner in the learning the new language(s). When first language habits help the learner to learn the new language, these habits are called positive transfer. However, if first language habits hinder the learner these habits are called negative transfer. Littlewood confines the term interference to denote negative transfer.

Littlewood (1994) notes two important types of interference during the learning of a foreign or second language. He calls these simple transfer and overgeneralisation. Littlewood recognised that these are not distinct processes, but are aspects of the same underlying learning strategy. Both result from the fact that the learner uses what he already knows about the language as support to acquire the new language/knowledge. In the case of overgeneralisation it is the previous knowledge of the second language that the learner uses, while in the case of simple transfer the learner uses his previous mother tongue experience as a means of organising the second language he is learning. These are the most common interference patterns faced

by science students in developing countries. For most of them their mother tongues are different from their instructional language.

To Ingram (1975) the learning of a language is like any other learning, in that it is heavily dependent on practice, repetition and imitation. Littlewood (1994) however believes that for concept learning, what is needed is a number of trials rather than a number of repetitions. In learning a scientific language the learner has to combine many demands of language acquisition and language learning, for instance the dual demands of language learning and concept acquisition.

Science teachers should develop within their students various skills of critical thinking. Chiras (1992) points out that if school systems spent more time teaching skills, students would become more efficient learners. To understand the proper meaning of words requires careful analysis of context. Concepts developed by language in the students' mind create a mental picture. This picture remains the model of that particular phenomena in understanding subsequent related concepts. Communication is only effective if those who transmit the message and those who receive it understand the same thing (Krashen, 1981; Krashen & Terrell, 1983; Watts & Gilbert, 1983; Ryan, 1985; Chiras, 1992).

Relating to these issues Stanton's opinion (1990b) is that the teaching process should accommodate students' ideas into a scientific framework constructed through interaction with the environment. The role of the instructional language during teaching ought to build scientific concepts and reshape students' ideas where they are not consistent with scientific ones. A language as a vehicle of communication develops stimuli in the mind. Through the word we visualise objects, and events.

2.6. ROLE OF PRIOR KNOWLEDGE IN SCIENCE

Researchers have observed that many science students develop "scientific" concepts that differ from acceptable scientific norms (e.g. Cohen et al., 1983; Stanton, 1990a). Often these misconceptions relate to the student's informal learning

environment before engaging in formal school science.

Cohen et al. (1983) note that the nature of science subjects is such that most topics are closely related to one another. Consequently what has been learned in one topic constitutes the pre-knowledge and useful pre-requisites for what will subsequently be learned. Ausubel stresses that learning is highly influenced by what the learner already knows (Moleli, 1992). This pre-knowledge interferes positively or negatively during learning of a new concept in formal science classes.

Science teachers aim to find or develop the most conducive teaching methodology to enable students to achieve a better understanding of what is to be taught. Teaching and learning any science is not simply the transferring and absorbing of new information, so that students become a "warehouse" of scientific terminology. Teaching and learning science entails the modification of a large part of a student's cognitive structure.

To Trowbridge & Bybee (1990) and Hadfield (1992), science teachers can only develop good teaching if they consider the extent and nature of prior knowledge that students have before instruction. Sometimes this knowledge is scientifically unacceptable and contradicts what is to be taught. Widdowson (1984) emphasizes that when students interact with the world around them they try to understand why things behave the way they do. Students develop personal ideas that help them to interpret and understand their environment. Some of these ideas are considered to be incorrect from a scientific point of view. They are nonetheless frequently well accommodated into the students' cognitive structure. It is these ideas that are referred to as children's science, alternative frameworks, misperceptions, alternative conceptions, misunderstandings, etc. (e.g. Osborne, 1980, quote by Moleli, 1992; Watts & Gilbert, 1983; Stanton, 1990b).

Stanton (1990b) notes some contrasting opinions and about students' perceptions, for example:

- To Fredette & Clement (1980) students' perceptions are concepts or ideas that students have prior to entering a course, and which have some consequence on their learning

within that course. A misconception is a conception or idea which from the point of view of the average professional leads to an unacceptable solution.

- To Abimbola (1988) the term misconception tends to be used by educators who think that students' prior knowledge is a potential barrier to learning new concepts. For some researchers (e.g. Hewson, 1981; Stanton, 1990b) the term "misconception" has negative connotations, implying that the idea is simply wrong.
- To Hewson (1981) alternative conceptions are prior knowledge that learners have about concepts or a conceptual environment. These cannot simply be dismissed, and are sometimes useful in anchoring a new concept, or reformulating old ones in a scientific way.
- This study will regard all students' non-scientific ideas about concepts and/or our environment as misconceptions.

The expression "students' environment" can be ambiguous. Hadfield (1992) states that a student's environment is the school and the classroom environment. He nonetheless warns that the role of the family in developing students' previous knowledge is also very important. Poynton's (1982) language and gender studies claim that the environment refers to all socio-cultural factors with which children are involved. Looking at these different opinions it is obvious that the expression "students' environment" is complex because it is constituted by all external factors around students - society, culture, language, family, classroom and school.

All these factors interfere with students' concept formation. Misconceptions are a world-wide issue. Misconceptions are held by students (and even by teachers) of all ages and all educational levels, and are often dependent on cultural background. Thijs and Berg (1996, quoted by Qhobela, 1996) exemplify the universality of misconceptions in different areas of physics. For example:

in mechanics, when students are asked to

- relate the concepts of "force" and "motion", or
- differentiate various aspect of motion;

in electricity, where research (e.g. Solomon et al. 1985; Shipstone, 1985; Stanton 1990a, 1990b, 1990c) shows that some students think that:

- the same amount of current is supplied by a battery, independent of the circuit connected, or
- the current is shared equally among the components in an electric circuit, or
- a cell is source of electric current.

Most of these ideas stem from students' personal observations and experiences. They are resistant to change during teaching and learning. Numerous studies (e.g. Widdowson, 1979; Strivens, 1980b; Widdowson, 1984b; Ryan, 1985; Sanders & Nhlapho, 1993; Rollnick & Rutherford, 1996) particularly emphasise that language is a primary source of misconceptions in science classes. The vocabulary used in science classes is a major problem.

According to Widdowson (1979 & 1984) and Strivens (1980b) there are different styles of a language for science and technology. Each has its specific demands. In developing countries (e.g. Mozambique), where for most students the instructional language is not the first language, scientific language imposes huge demands: the indigenous language(s) lack suitable properly differentiated scientific vocabulary (Krashen, 1981). Scientific language strives to be more precise (Bulman, 1980) than is the norm in ordinary everyday language.

Other studies (e.g. Bulman, 1980; Krashen, 1981; Sanders & Nhlapho, 1993) highlight that there are other types of words that hinder scientific information in science classes such as:

- Non-technical terms - also called words for junction or linking words, e.g. words such as: "because", "as", "then", "therefore", "however" ...;
- Paradoxical Jargon (see page 10).

Bulman (1980) stresses that words such as "force", "energy", "power" and "work" that have specific meanings in science, rather different from everyday familiar meanings, often confuse students, and are a source of special difficulties in learning science.

Science students, after learning that the meaning of some words can change in the specific context of the subject, and knowing that scientific language desires to be more precise, then find that other words and phrases which are used (e.g. "most", "as", "simultaneous", "abundant" ...) which are not necessarily scientific, also become a source of difficulty in the classroom or science textbooks. These words interfere in students' learning, because they hesitate while evaluating the strength of the word (Bulman, 1980; Sanders & Nhlapho, 1993). Bulman (1980) warns that these words, not directly connected with any specific subject, place a barrier between the student and the information, so hindering comprehension and communication.

The effect of previous knowledge (e.g. culture, family) on learning sciences is very strong. Researchers such as Bulman (1980) and Rollnick & Rutherford (1996) point out that the personal construction of meaning is related to the linguistic background of the learner. The lack of an appropriate language background will interfere negatively in students' understanding in science classes. The teachers' language in science classes, and the language used in textbooks, has a direct impact on students' acquisition and assimilation of new scientific conceptions.

CHAPTER 3

DESIGN AND METHODOLOGY

3.1. INTRODUCTION

In Chapters One and Two we analysed the role of language in education, more particularly in science education, as a vehicle for communication. The main point was how to minimise the negative influence of students' previous knowledge in understanding fundamental electric concepts. The objective of this study is to find out IF, and HOW, the mother tongue (Chope) interferes with students' understanding of these concepts. This chapter discusses procedures used to achieve these objectives.

3.2. RESEARCH INSTRUMENTS

As instruments to collect data we chose:

- a written task, in the form of a questionnaire, as the main tool; and
- a semi-structured interview for just a few Chope students; used as an auxiliary instrument only.

The written task is shown in APPENDIX 1. It was intended to assess students' understanding of fundamental electric concepts in Portuguese (instructional language in Mozambique), and to search the role of Chope (the mother tongue) in the learning of these concepts, and some other scientific terms related to electricity.

The written task was compiled by the researcher, and comprises two parts, Questionnaire 1 and Questionnaire 2.

In Questionnaire 1, students were asked to explain how they understood twenty electric terms in Portuguese and in Chope. For each task they were asked to indicate the level of confidence they had in their response. The twenty terms selected covered three areas:

- Pre-requisite electric concepts: energy; electric field; load; electric charge; electricity; work.
- Basic concepts of DC circuits: electric resistance; current

intensity; insulator; electric power; conventional current; electric circuit; electric current; parallel electric circuit; potential difference; source of electromotive force.

- Circuit components and instruments: voltmeter; switch ("interrupter"); (metal) wire; battery.

In compiling the questionnaire, the three categories of concepts were randomised.

Questionnaire 2 consisted of two subparts, B.1 and B.2. In B.1 students had to translate three scientific sentences, written in Portuguese, into Choape. In B.2 they had to translate two questions from Portuguese to Choape, and then answer them into Choape.

The second instrument was the interview, which collected students' knowledge related to electrical terms. This auxiliary instrument was used to collect information about the mother tongue because Mozambican mother tongues do not have a written tradition. Students' writing skills in their mother tongues are generally weak.

The questionnaires described above were administered to all BUSCEP students in the first week of November 1997. This time was chosen because the topic on electricity is taught from the end of October, and the researcher wanted to know what knowledge BUSCEP students had on electricity after having done revision on important pre-requisite concepts (e.g. potential difference, electric field), but before instruction on the further content of the BUSCEP electricity course (Unruh, Li, Meng & Zhang, 1997).

The test was administered to ALL students, and in this process the Choape speaking students required for later study were identified. Of the approximately 300 students, twenty-eight were Choape speakers.

Questionnaire 2 (sections B1 and B2) was restricted to twelve students out of the 28, who had shown a reasonably acceptable level of competence in answering in Choape.

Six students were selected for the interview. These were:

- Two students who showed good writing skills in Choape. Their translations were scientifically acceptable and

internally consistent ("good" students).

- Two students who gave many scientifically acceptable responses (in Portuguese) but also asserted many times (in Chope) that they are only able to respond orally.
- Two students who gave many scientifically and internally unacceptable responses ("weak" students).

3.3. DATA ANALYSIS

The purpose of the above instruments was to investigate:

- students' understanding of the twenty terms related to electricity, such as electric current, resistor, potential difference (voltage), electric power;
- prior knowledge (as expressed in Chope) that might help or hinder the learning of fundamental electric concepts;
- the language in which students can better or more clearly explain their ideas;
- students' attitudes to language when they find words not translatable in Chope;
- the kinds of translations used by students in scientific sentences.

To achieve these objectives the researcher adopted the following procedures:

3.3.1. Data from the written task

a) Questionnaire 1

Firstly, the questions were grouped into specific sub-groups:

- Pre-requisite electric concepts:
 - Q1: energy
 - Q7: electric field
 - Q11: load
 - Q13: electric charge
 - Q19: electricity
 - Q20: work
- Basic concepts of DC circuits:
 - Q3: electric resistance
 - Q4: current intensity
 - Q6: insulator
 - Q8: electric power
 - Q9: conventional current
 - Q10: electric circuit
 - Q12: electric current
 - Q14: parallel electric circuit

- Q16: potential difference
- Q17: source of electromotive force

● Circuit components and instruments:

- Q2: voltmeter
- Q5: switch ("interrupter")
- Q15: (metal) wire
- Q18: battery

After this the researcher analysed, question by question, the responses in Portuguese and Chope for each student. The responses were coded and summarised in the tables given in APPENDIX 2.

For each question, a commentary was compiled on main features of the responses in Portuguese and Chope, as well as notes on consistencies or inconsistencies in the two languages.

After this we attempted to look for commonalities across the sub-group, and this analysis is summarised in Tables to be discussed in Chapter 4. We looked for particular responses considered to be influenced by local factors (e.g. language, economic, childhood environment). The intention was to find out how students relate Chope, Portuguese and descriptions of electric concepts.

b) Questionnaire 2

This questionnaire consisted of two sub-sections: B1 and B2. These were related to translations and students' answers about specific sentences and questions respectively. Students' responses were coded and summarised in the Tables given in Chapter 5. A qualitative analysis was done on these responses.

c) Finally, we compared the comments and conclusions made about the two questionnaires (Chapter 6).

3.3.2. Data from tapes

The objective of the tape recordings was to assess:

1. students' speaking performance in Portuguese;
2. students' declared understanding of scientific terms used electricity;
3. students' speaking performance when using scientific terms in Chope.

The tapes were used as a reference only - to refer back to particular points - and no transcripts were made.

CHAPTER 4

ANALYSIS OF QUESTIONNAIRE 1

4.1. INTRODUCTION

This Chapter analyses the level of students' performance as they explain their understanding of a list of twenty fundamental electric concepts in Chope (their mother tongue), as well as how they understood the same concepts in Portuguese (Mozambican instructional language). The concepts investigated fall into three categories:

- **Pre-requisite concepts**
(Questions: 1, 7, 11, 13, 19 and 20);
- **Basic concepts of DC circuits**
(Questions: 3, 4, 6, 8, 9, 10, 12, 14, 16 and 17);
- **Circuit components and instruments**
(Questions: 2, 5, 15 and 18).

The questionnaire was administered to all BUSCEP students, but this detailed analysis of responses is given only for the twenty-eight Chope speaking students who responded in Portuguese and Chope.

Tables were prepared for each question, in which the responses were coded according to the main idea presented. Codes are indicated in the key at the bottom of each table.

- A response is indicated as "**".
- A blank is indicated as "-".
- Where students gave other responses outside of the categorised main ideas, this is indicated as "O".
- For the Chope part of the questionnaire, some students indicated they could not give a written Chope response, but would be able to respond by speaking ("S") about it.
- A completely blank response, i.e. no response in either Portuguese or Chope is indicated as "-/".
- A student who claims, either in Portuguese or in Chope, that he/she has no idea whatsoever idea about the concept asked, is indicated as "D".

- "-/" and "D" responses effectively decrease the number "N" of respondents.
- The last column denoted "comments" was used to assist in looking for consistency in explanations across/between languages, or students that gave two different ideas in the same language (inconsistent explanation in the same language).
 - For consistent explanations across/between languages we have used bold comments (e.g. F-I and C-G).
 - For two different ideas in the same language (either Portuguese or Choze) we have used italics (e.g. F-C and I-G).

This column assists in looking for other information such as:

- A completely blank response in both languages;
- The effective number of respondents;
- The relationship between responses in Portuguese and in Choze;
- Single responses (i.e. responses in either Portuguese or Choze, but not both).

4.2. PRE-REQUISITE ELECTRIC CONCEPTS (Questions 1, 7, 11, 13, 19, 20)

4.2.1. QUESTION 1 (Energy) (TABLE 4.2.1 of APPENDIX 2)

Students gave THREE main ideas about ENERGY in Portuguese:

- E: Energy enables an object to do work;
- F: Energy is a force produced or necessary to do work;
- C: Energy is electric current.

In Choze there were TWO main ideas:

- I: Intamo (force);
- G: Guezi (electricity, electric current).

DISCUSSION

a) Responses in Portuguese

Nine students recalled the textbook definition of energy as the ability/capacity of an object to do work. Only one student, C8, particularly connected electrical energy and electrical work by mentioning in his response an electric object. The other eight

did not relate the question to electricity. These respondents were all male. Some responses were:

C5: P: Energia é a capacidade de realizar trabalho
E: Energy is the capacity to do/realise work

C8: P: Energia eléctrica é a capacidade que um corpo eléctrico tem de realizar trabalho
E: Electric energy is the capacity that an electric object has to do/realise electric work

Seven students (5 male(m), 2 female(f)) understood energy as a force produced or necessary to do work. Eight students (3m, 5f) defined energy as electric current. Five students (2m, 3f) defined energy as heat or transformed/transferred heat that became work. Some students responded in more than one way. For example C1 and C2 both gave two responses. The following response was identical for both:

P: Energia é quantidade de trabalho que uma força realiza ao longo de um deslocamento
E: Energy is the quantity/amount of work that is done/realised by a force when moving something (changing position)

The following responses were similar:

C1: P: Entende-se também por energia a força da corrente eléctrica que é usada nos rádios, gravadores (aparelhos eléctricos)
E: Understanding also that energy is the electric current force used in electric instruments such as radios, tape records

C2: P: Energia é a força eléctrica
E: Energy is electric force

Although this study does not specifically address gender issues, it seems that females prefer to define energy as electric current or transformed energy. Males prefer to define energy as a force, or force necessary to carry or push something, i.e. to do work. Some miscellaneous "definitions" are given in the following examples:

C16: P: Energia é quantidade de calor
E: Energy is the quantity/amount of heat

C17: P: Energia é temperatura
E: Energy is temperature

C19: P: Energia é fluxo de electrões num determinado conductor
E: Energy is electrons flowing in a conductor

b) Responses in Choqe

Eleven students understood energy as intamo (force), while four understood energy as guezi (electric current or electricity). Three could not write in Choqe. Seven left the answer blank and three gave vague and/or ambiguous responses. This seems to show

that students are unaccustomed to responding IN WRITING in Chope.

c) COMMENTS

Seven students were consistent in their understanding in both Portuguese and Chope. For five students energy is force (Portuguese) and intamo (Chope) (F-I), while for two students energy is electric current (Portuguese) and guezi (Chope) (C-G). These responses were scientifically unacceptable although internally consistent.

Seven students (3m, 4f) gave two inconsistent ideas about energy in the same language. For two students (1m, 1f) energy is the force necessary to do/realise work and the capacity to do work. For three female students energy is electric current and heat or transformed/ transferred heat (in Portuguese), while for another two male students it is intamo and guezi (Chope).

Seven students had a language problem. Their answers were acceptable in Chope, but became incorrect when they wrote them in Portuguese, because the words intamo and guezi have more than one meaning in Chope. They chose a non-applicable word in Portuguese, thus apparently destroying their intended scientific meaning.

4.2.2. QUESTION 7 (Electric field) (TABLE 4.2.2 of APPENDIX 2)

Students gave only ONE main idea about the ELECTRIC FIELD in Portuguese:

E: The electric field is an area around an electric charge where the effect of the charge is felt.

In Chope they also gave ONE main idea:

U: *Ukalo kumbe yi thembwe ku pfalaku intamo wa guezi* (area, place or region where an electric force is felt).

DISCUSSION

a) *Responses in Portuguese*

Fifteen students understood an electric field as a space or area around an electric charge where the effect of the charge can be felt. Many students (e.g. C2, C18, C15) define the electric field in the following way:

- P: Campo eléctrico é um espaço ou area a volta duma carga eléctrica ou dum corpo electrizado onde se faz sentir o efeito or força exercida por uma carga eléctrica
- E: The electric field is a space or area around an electric charge or any electric object in which the effect or force exerted by these electric charges (electric objects) can be felt

Nine students gave different explanations :

- C8: P: Um campo eléctrico é um lugar onde existe electricidade
E: An electric field is a place where electricity exists
- C19: P: Um campo eléctrico faz se sentir nos arredores de um iman. Por exemplo aproximamos um iman a pedaços de ferro eles são atraídos devido ao campo eléctrico nos arredores do iman
E: An electric field is felt around a magnet. For example, when a small piece of iron is put close to a magnet it is attracted, because an electric field exists around a magnet

C8 is very vague, while C19 is confused between magnetic and electric fields!

b) Responses in Chope

Eleven students defined an electric field as the region or field in which the electric force or force of electricity can be felt:

- C2: Ch: Electric field ukalo kumbe yi thembwe ahawa (amua) kuphalako intamo wa guezi
E: Electric field is a field/limited area in which the force of electricity (or electric force) can be felt

In these responses an expression for electric charge does not appear. This suggests that in Chope an expression for electric charge is non-existent or uncommon. Four students asserted they were able only to respond orally. Two gave unqualifiable ideas, while eight left the response blank. Three students had no idea what an electric field is.

c) COMMENTS

Eight students gave consistent answers in both languages (7 E-U and 1 D-D). The former, (E-U), understood an electric field as an area around an electric charge where the effect of this charge can be felt (Portuguese), while in Chope they give ukalo kumbe yi thembue ku phalaku intamo wa guezi (area, place or region where an electric force is felt). This conveys the same general idea, except that they cannot use the expression electric charge or another equivalent, but it is implicit that something creates a field around the charge, i.e., there is a source of the electric field.

4.2.3. QUESTION 11 (Load) (TABLE 4.2.3 of APPENDIX 2)

Students gave TWO main ideas about a LOAD in Portuguese:
E: A load is anything that it is carried/delivered;
Q: A load is the quantity of electrons transported by the electric current.

In Chope they gave TWO main ideas:

- I: Intualo/inthualo kumbe tchidjumba (anything that it is carried/transported);
G: Intamo wa guezi (electric force or force of electricity).

DISCUSSION

a) Responses in Portuguese

Fourteen students out of 25 understood a load as anything that has weight, or that can be transported by a lorry, animal...

- C2: P: Carga é tudo o que pode ser transportado
E: Load is anything that should be transported

- C12: P: Carga é tudo, é peso de coisas, podemos sentir
E: Load is anything, is weight of things/goods that we can feel

Ten students (e.g. C7, C25) understood a load as a quantity of electrons that a body has, while for C19 a load is a quantity of energy that a body has:

- C25: P: Carga é quantidade de electrões ganho ou cedido por um elemento químico
E: Load is quantity of electrons acquired or given by a chemical element

Six responses incorporated both ideas:

- C13: P: O conceito carga é tem muito significados, é mercadoria, algo que se pode carregar num camião, navio, por uma pessoa etc. Outro significado é, carga é uma partícula que possui excesso the electrões u de protões, também a quantidade de chuva.
E: The concept load has more than one meaning. Load is a commodity, something that can be carried/transported by a person, car, lorry shi etc. Another meaning of load is a particle that has an excess of electrons or protons. Also a load is a quantity of rain.

b) Responses in Chope

Twelve students understood a load as inthualo kumbe tchidjumba (bundle or anything carried by a vehicle or animal):

- C1: Ch: Carga, simaha si rualuako nguthu, ngumwa, ngutchi-kotchikana, in thengo wa intamo wa guezi kumbe ditsui na mathi ya ndzumani
E: Load is anything that we can carry by car, wagon; is quantity/volume of electric force; is quantity of water that falls in a short time when it is raining

Six students related load with electric current. For them, load is intamo wa guezi (electric force or force of electricity).

c) COMMENTS

In Portuguese the concept load is called carga (charge). Thus the word carga invoked many ideas in students' meanings:

- * carga meaning a load;
- * carga meaning an electric charge;
- * carga meaning a volume or quantity.

Responses called "special" in Table 4.2.3 (e.g. E-Q, I-G) suggest that students know the importance of being precise when talking or writing, otherwise words develop different meanings or change meanings in specific contexts.

Fifteen students gave consistent responses across both languages. For eleven students (11 E-I) a load is anything that is carried (Portuguese) and intualo/intualo kumbe tchidjumba (Chope), meaning the same as the Portuguese. Four students (4 Q-G), understood load as an (excess) quantity of electrons that a body has (Portuguese), and as intamo wa guezi which can mean an electric quantity (Chope).

4.2.4. QUESTION 13 (Electric charge) (TABLE 4.2.4 of APPENDIX 2)

Students gave THREE main ideas about ELECTRIC CHARGE in Portuguese:

- C: It is an accumulation of electricity or electric capacity;
- P: It is an electric particle;
- A: Different explanations - but internally consistent.

In Chope, they gave only ONE main idea:

- I: Intamo wa guezi (electric force or force of electricity).

DISCUSSION

a) Responses in Portuguese

Nine students understood electric charge as a quantity of electricity produced and accumulated or as a quantity of energy in an electrical device.

- C5: P: Carga eléctrica é a quantidade de energia acumulada por certos elementos eléctricos tais como: acumuladores, baterias or capacitores
E: Electric charge is a quantity of accumulated energy by certain electric elements, such as: accumulator, battery, capacitor

- C1: P: *Carga eléctrica é a quantidade da electricidade produzida e acumulada*
 E: Electric charge is a quantity of electricity produced and accumulated

Some of these responses are ambiguous or imprecise. C1 does not clarify WHAT is produced or HOW it is accumulated.

Four students (e.g. C11, C15) understood electric charge as a small particle which has the coulomb as unit:

- C23: P: *Carga eléctrica é a capacidade de armazenamento de energia eléctrica que um corpo possui, é uma pequena partícula que tem como unidade coulomb*
 E: Electric charge is the capacity that an object has to store electric energy. It is a small particle with coulomb as unit

Six students gave different explanations:

- C12: P: *Carga eléctrica é peso*
 E: Electric charge is weight
- C26: P: *Carga eléctrica é a matéria que uma partícula transporta*
 E: Electric charge is material/substance that a particle "delivers"

Students' explanations were influenced by the "key word". The expression "electric charge" consists of the two words - "electric" and "charge". Students took as the key word "charge", understood as "load". The source of misunderstanding was a local factor (ordinary meaning of the word "charge" ([load in Portuguese])).

b) Responses in Choqe

Two students understood electric charge as electric force or force or electricity. Three students claimed they were only able to answer orally, while another 13 students asserted they had no idea what electric charge is.

Responses showed that the concept is uncommon in Choqe. Hence students' knowledge about electric charge is very weak.

c) COMMENTS

The concept of electric charge is difficult for many students, as evident in responses in Choqe as well as in Portuguese. Fourteen students had no idea what electric charge is in either Choqe or Portuguese. Answers showed that many students responded in Portuguese without any previous knowledge as foundation in Choqe.

4.2.5. QUESTION 19 (Electricity) (TABLE 4.2.5 of APPENDIX 2)

Students gave THREE main ideas about ELECTRICITY in Portuguese:

M: It is electric current motion or motion of electric charge;

C: It is a "Chapter of Physics" or science which studies electric phenomena;

Q: It is heat or calorific energy.

In Chope, students gave TWO main ideas:

N: *Yi guezi kumbe indilo wa guezi* (electricity or electric current);

*N: *Indilo wa guezi* (electric fire or fire of electricity).

DISCUSSION

a) Responses in Portuguese

Five students understood electricity as a motion of electrons or electric current supplied by a generator:

C17: P: *Electricidade são associações de electrões em movimento*
E: Electricity is the motion of an association of electrons

C1: P: *Electricidade é uma corrente eléctrica produzida por um gerador*
E: Electricity is an electric current produced by a generator

These responses are not completely acceptable. What kind of motion do the electrons have? What is an "association of electrons"? Students showed a common misunderstanding that a generator supplies electric current, rather than being primarily an energy source.

Seven students recognise electricity as a science or "Chapter of Physics" which studies electric phenomena:

C22: P: *Electricidade é um capítulo que retrata o estudo geral do movimento de electrões*
E: Electricity is a chapter, which looks at the general study of the motion of electrons

C4: P: *Electricidade é a ciência relacionada com corrente.*
E: Electricity is the science related with current

Seven students understood electricity as heat or calorific energy or light. Responses showed that students related electricity with an activity of sorts.

b) Responses in Chope

Six students understood electricity as *indilo wa guezi*, i.e. electricity relates to heat or light. Eleven students understood electricity as *guezi*, (electricity or electric current, a general

"definition" of electricity in Chope):

C4: Ch: *Indilo wa guezi*
E: Electricity is light/heat (is fire of electricity)

C1: Ch: *Electricidade yi guezi*
E: Electricity is electric current/is electricity.

Two students claimed no idea about what electricity is, while another two asserted they were only able to answer orally.

c) COMMENTS

Electricity is familiar to many students. However they have a different idea of it in Chope and in Portuguese. In Portuguese students have more than one perception, while in Chope there is basically only one idea (*electricity yi guezi, indilo wa guezi*).

The expression *guezi* in Chope has more than one meaning: it is difficult to assess if students who responded "-"-N or "-"-*N had guessed responses, or whether they understand the concept of electricity better in Chope than in Portuguese.

As in Question 1 on energy, females prefer to relate electricity with heat.

4.2.6 QUESTION 20 (Work) (TABLE 4.2.6 of APPENDIX 2)

Students gave THREE ideas about WORK when responding in Portuguese:

- W: Force times displacement;
- P: Displacement created or produced by a force;
- E: Result of a force done by an animal, person or engine.

In Chope students also gave THREE ideas:

- K: *Inthumo kutikaratta kumbe kutchukumangu tchomaha* (effort to achieve anything);
- I: *Inthumo* (work);
- N: *Ndjikombitso tcha inthumo wanthu* (work is something that a person made/did which can state/show).

DISCUSSION

a) Responses in Portuguese

Five students recalled textbook definitions to explain how they understood the concept work, of whom two recalled equations:

- C22: P: *Trabalho é o produto de uma força pelo seu deslocamento, que pode ser positivo ou negativo dependendo da força aplicada em relação ao referencial*
- E: Work is a result/product of force times displacement originated by action of the force. The work should be positive or negative according to the action of the force on the object in relation to the reference

- C11: P: Trabalho é o resultado da variação de energia devido a decapitação desta durante o deslocamento dum corpo
E: Work is the result of a variation of energy, because of transformation of energy during displacement of the object

Seven students understood work as a displacement created by force applied to an object:

- C8: P: Trabalho é um deslocamento produzido por uma força
E: Work is a displacement produced by a force

Nine students understood work as result of force done by an animal, person or engine:

- C16: P: Trabalho é a força que um homem faz ao realizar as suas actividades, para o seu bem
E: Work is the force done by a man when he is realising/doing a task/activity useful for himself

- C5: P: Trabalho é acção de executar uma tarefa
E: Work is action to realise a task

Four students stated different perceptions:

- C17: P: Trabalho é uma força produzida por um movimento de um homem, animal, ou um aparelho
E: Work is a force produced by a motion of a person, animal or apparatus

What do students intend by force produced by motion?

b) Responses in Choqe

Two students gave internally consistent answers, understandable to any Choqe speaker.

- C16: Ch: Inthumo/intumo ikutikarata kumbe kutchukumaka inthu a tchilava tchamaha
E: Work is the effort made by anyone when they wish to achieve something (or work is effort to achieve something)

Eight students defined work as *inthumo* without any comment. Responses showed that students were influenced by local factors and common understandings. The concept *inthumo*, as with the concepts *guezzi* and *intamo*, has more than one meaning, and the intended meaning can only be conveyed within a specific context.

Five students understood work as *njikombitso tcha inthumo*, meaning the result or something that "can be stated", or done by a person:

- C5: Ch: Inthumo ngu ti amahaku inthu tikuni tchatchazelo
E: Work is anything that is done by man and produces a result
- C12: Ch: Inthumo ngumaha txomaha ngu ndzila yo uoneka
E: Work is to do something that can be stated or anyone can appreciate

a) COMMENTS

For many students the concept of work is very familiar within the

ordinary vocabulary. In spite of this, they found it difficult to explain. As with the previous question (Q19) on electricity, one reason is weakness in Portuguese, and the inability to use language to get to the specific meaning within a scientific context. Nobody left the response blank in Portuguese, while in Chope nobody claimed they had no idea about the concept, although five left the response blank.

4.2.7. GENERAL ANALYSIS OF PRE-REQUISITE ELECTRIC CONCEPTS (Questions 1, 7, 11, 13, 19, 20)

We now give a general overview of the whole sub-group of questions relating to PRE-REQUISITE ELECTRIC CONCEPTS.

We looked at how prior knowledge in Chope may interfere with the learning of these pre-requisite concepts. Other "local" factors (e.g. common usage, childhood environment) were noted where of interest.

Students' responses were coded and summarised in TABLE 4.2.7.1 and TABLE 4.2.7.2 on page 38.

It was generally observed that before the BUSCEP course, students had some limited acquaintance with fundamental electric concepts. However, although they are able to manipulate some electric instruments (e.g. cell, ammeter, interrupter), few are able to give acceptable/scientific arguments about their knowledge regarding the fundamental principles of electricity.

Energy and electricity

When students respond in Portuguese, many give scientifically unacceptable explanations for concepts such as energy (Q1) and electricity (Q19) although these explanations were sometimes internally consistent. In Q1, for instance, 21 students out of 27 used "common" definitions/explanations to describe energy, such as energy is a force necessary to do work or energy is electric current.

It was evident that students understand energy as an obvious activity, i.e. energy is related to any activity, or work; or energy as electric energy is something that is useful (e.g. to light bulbs or heat an iron or stove).

In Q19 (electricity), 17 responses were influenced by "local

TABLE 4.2.7.1: Summary - Pre-requisite concepts (Chope)

Students' responses in Chope						
Questions						
Code	Q1 Energy	Q7 Electric field	Q11 Load	Q13 Electric charge	Q19 Electricity	Q20 Work
E	0	10	12	0	6	5
G	15	11	6	0	0	2
M	15	0	6	5	17	8
W	3	2	1	3	0	1
D	0	3	0	10	2	0
B	7	8	4	3	3	5
S	3	2	6	3	2	4

Code

- E: Student gave unacceptable "definitions" or expressions influenced by local factors;
 G: Student did a good translation into Chope, and showed good understandings in Chope. His/her understandings are scientifically acceptable, and can be understood by any Chope speaker;
 M: Student used general definitions without any explanation;
 W: Student gave incorrect response;
 D: Student claimed no idea what the concept is;
 B: Student left the response blank;
 S: Student claimed he/she can only respond orally.

TABLE 4.2.7.2: Summary - Pre-requisite concepts (Portuguese)

Students' responses in Portuguese						
Questions						
Code	Q1 Energy	Q7 Electric field	Q11 Load	Q13 Electric charge	Q19 Electricity	Q20 Work
R	9	15	0	4	0	5
A	0	0	10	9	5	0
E	21	0	24	0	13	9
W	10	9	11	6	7	11
D	0	1	0	0	0	0
B	0	1	3	4	5	0

Code

- R: Student recalled textbook definition to explain his/her understanding about the concept
 A: Student gave acceptable definition in his/her own words
 E: Student gave unacceptable definitions or expressions influenced by local factors
 W: Student gave incorrect response
 D: Student claimed no idea what the concept is
 B: Student left the response blank

factors". For instance ten students saw electricity as *indilo wa guezi* (electric fire or fire of electricity). This understanding is created by how students interact with electricity. Many of them use electricity in their everyday life to iron their clothes, or to cook their food or to light bulbs. All these phenomena are related with heat.

Load

In Q11, 24 students understood a load (charge in Portuguese) as something that is carried or can be transported. This understanding was also showed by students who understood load as electric charge. For these students electric current is something that flows carrying electrons (i.e. a load).

Electric charge and field

However when students consider concepts such as electric field (Q7) or electric charge (Q19) (concepts uncommon to the students' ordinary vocabulary or everyday life), they recall textbook definitions, or support their explanations with knowledge acquired in science classes (in Q7, 15 students out of 25 gave textbook definitions)

Students' strategies for defining an electric field in Chope were as follows: The concept of an electric field is constituted by two words "electric" and "field". Students chose the word field as the key word to understand the concept. The concept of a field (area around under influence of... OR limited region) is very familiar to any Chope speaker. Students associate the word "field" with the expression *intamo wa guezi* (force of electricity OR electric force). Through this procedure they understand electric field as *ukalo kumbe yi thembwe ku pfalaku intamo wa guezi* (area around a charge where an electric effect is felt). The same strategy was applied for Q13 (electric charge) but students' understanding of the key word "charge" was scientifically incorrect so that their understanding of the concept electric charge was also wrong.

Students' understanding of the electric field is based on analogy and association of previous knowledge. Sometimes this procedure is not useful due to the multi-meaning of Chope words. For example the expression *intamo wa guezi* also characterises the

intensity of the electric field. However a good speaker of Portuguese or Choape is able to recognise within the context when the expression *intamo wa guezi* (electric force) means the area under the influence of the field, or when it characterises how the force of the interaction is felt.

Work

The concept work (Q20) is (like load, electricity and energy) very familiar to many students. Nonetheless they have differing perceptions. They understand that the everyday definition of work is not scientifically acceptable, so they avoid giving a "common" explanation. But they also do not know how to define the concept scientifically, although they have a vague idea they should include the concepts "force" and/or "displacement".

When students respond in Choape about concepts that are common in everyday life, they prefer to "translate" the content, or explain in their own words how they understand the concept. Often students support their explanation with ordinary knowledge acquired from local factors, or use a common "definition" without giving any explanation (another impact of local factors). For instance in Q1, some students who understood energy as electric current or electricity gave a common definition, or *electricity: intamo wa guezi* (electric force or force of electricity). Their explanation/understanding is internally acceptable in Choape.

Responses in Choape show that students understand most of the pre-requisite concepts used for this research as *guezi* (electricity or electric current), *intamo wa guezi* (electric force or force of electricity) and a few as *indilo wa guezi* or *intsengo wa guezi* (electric fire or fire of electricity). Choape is characterised by a weak vocabulary i.e. one word in Choape covers many concepts.

Students' misunderstandings in Choape can hinder their scientific understanding: for instance, while in Choape the expression *intamo wa guezi* (electric force) characterises many electric concepts, in Portuguese we have an expression for each concept.

4.3. BASIC CONCEPTS OF DC CIRCUITS (Questions 3, 4, 6, 8, 9, 10, 12, 14, 16, 17)

4.3.1. QUESTION 3 (Electric resistance) (TABLE 4.3.1 of APPENDIX 2)

Students gave only ONE main idea about **ELECTRIC RESISTANCE** in Portuguese:

M: Electric resistance is a friction or frictional force which opposes the motion/flowing of electric current (NOT generally regarded as a quantitative measure of this opposition).

In Choze they gave TWO main ideas.

T: *Intamo wa kuti tchukumisa ka waiela loko yi tchipfalela guezi* (Force/effort opposing the passage of electric current in a wire);

B: *Njlmaha tchitsimbako ku guezi yi phinda yotse ka waiela* (Something which prevents all/whole electric current passing through an electric wire, or devours/uses electric current when passing through the wire).

DISCUSSION

a) Responses in Portuguese

Fifteen students understood electric resistance as a feature of electric elements that hinders the electric current, or as a friction in the wire that opposes the flowing/motion of electric current as it is passes through the wire. Some responses were:

C9: P: *Resistência eléctrica é a condição desfavorável que os materiais oferecem a condução da corrente eléctrica, isto é, a capacidade eléctrica dos fios eléctricos*

E: Electric resistance is an undesirable condition of a material for conduction/flow of electric current, i.e. is the electric capacity of the electric wire

C24: P: *Resistência eléctrica é a força de atrito que os fios exercem sobre a corrent eléctrica*

E: Electric resistance is the friction force that the wire has for electric flow

Other responses were unqualifiable, vague or confused. e.g.

C9: P: *Resistência eléctrica é a capacidade de energia que o corpo possui ou seja é a voltagem de um determinado corpo*

E: Electric resistance is the energy that something has, i.e. is the voltage of any object

b) Responses in Choze

Five students defined electric resistance as the size/level of the opposition to the motion of electric charge:

- C12: Ch: *Tchikaratu kumbe ngu intamo wa kuti tchukumisa ka waiela loko yi tchi pfalela guezi*
 E: Is the effort or the value of the effort which is done by the electric conductor when doing/making a barrier for current flowing or to block electric current
- C24: Ch: *Tchisinamiso tchikombako kuhambana ka mi mo wa mawaiela ya guezi*
 E: Is the amount that represents the difference in value of the level of opposition of different electric conductors

Five students understood electric resistance as "something" that develops a barrier to electric current when it is flowing through an electric wire, or as something that "devours" or "uses" electric current in an electric wire. e.g.:

- C28: Ch: *Electric resistance njimaha tchitsimbako ku guezi yi phinda*
 E: Electric resistance is something that does not allow all the electric current/electricity to pass through an electric wire

C10 gave a rather lengthy explanation:

- C10: Ch: *Resistance electric intamo uo kuti tchukumissa ka waiela ya guezi loko yi tchi pfalela guezi kuva yi tsi phindi inka waiela. Loko intamo wa kuti tchukumissa ini wa hombe niresistenci electrica do pfala yotse guezi hambu nkui tumissa yotse.*
 E: Electric resistance is the friction of the electric wire, which hides the motion of electric charge through it. When the value of friction is high electric resistance could block/close all electric current or use or consume/devour it completely.

Three students claimed they could only give the answer verbally.

c) COMMENTS

Five students defined correctly what electric resistance is in Choqe, but many explanations in Portuguese were not scientifically acceptable. Even students that showed good understanding in Choqe gave vague and inconsistent explanations in Portuguese.

Four students gave consistent responses (M-B) in both languages. Electric resistance is "friction that blocks/hides the motion of electric current through an electric wire" (Portuguese), while the same idea is conveyed in Choqe: *njimaha tchitsimbako kumbe tchi pfalelako guezi kuva yi phinda yotse inka waiela.*

The response combinations M-"-" and O-"-" suggest that some students prefer to give responses in Choqe only when they have confidence with these responses. When answering in Portuguese they guess the response rather than claim they are unable to give any answer. Eleven students left the answer blank in Choqe but gave vague and inconsistent answers in Portuguese.

Four students who gave correct explanations in Chope - *Intamo wa ku tchukumissa* or *tchisinamisso tchikombaku* (quantity or value of opposition of passage of electric current) - answered incorrectly in Portuguese (M-T). Again the multi-meaning of *intamo* and the choice of a non-applicable word in Portuguese caused misunderstanding with the Portuguese response.

4.3.2. QUESTION 4 (Electric current intensity) (TABLE 4.3.2 of APPENDIX 2)

Students gave only ONE main idea about ELECTRIC CURRENT INTENSITY in Portuguese:

Q: Electric current intensity is the quantity of electric charge flowing into an electric conductor/element per unit time.

In Chope, students gave TWO main ideas:

I: *Intamo wa guezzi* (Electric force);

M: *Intsengo kumbe imphimo wa guezzi yi phindako ku* (The quantity of electric current or electricity that passes through).

DISCUSSION

a) Responses in Portuguese

Fourteen students recalled the textbook definition:

- C13: P: *Intensidade da corrente eléctrica é o valor, a quantidade, da corrente eléctrica que atravessa um(a) secção dum conductor por unidade de tempo*
E: Electric current intensity is the value, the quantity, of electric current which crosses or flows through an electric conductor per unit time

Eleven students stated different ideas:

- C4: P: *Intensidade da corrente eléctrica é a força com que a corrente se manifesta*
E: Electric current intensity is the force manifested by the current
- C1: P: *Intensidade da corrente eléctrica é o volume ou poder da corrente eléctrica*
E: Electric current intensity is the volume or power of the electric current
- C26: P: *Intensidade da corrente eléctrica é o poder ou a força que a corrente eléctrica tem*
E: Electric current intensity is the power or force that the electric current has
- C19: P: *Intensidade da corrente eléctrica é corrente eléctrica intensa, isto é, forte*
E: Current electric intensity is intense electric current, i.e., strong

What did students have in mind when using the underlined words?

b) Responses in Choape

Seven students understood the concept of current intensity as intamo wa guezi (electric force or force of electric current or electricity):

C13: Ch: Intensidade da corrente eléctrica intamo wa guezi
E: Electric current intensity is electric force

C18: Ch: Intensidade da corrente eléctrica intamo wa guezi yi tsimbilako ka ngoty ya guezi
E: Electric current intensity is electric force of current that is flowing into electric wire

Four students understood current intensity as the quantity of current or electricity that flows through an electric wire or electric element:

C3: Ch: Intensidade da corrente electrica intsenko ou imphimo wa guezi yi phindago inkga si gotso sa kum inkama uo kari
E: Electric current intensity is the amplitude or quantity of electric current or electricity that flows into electric elements per unit time

The remaining responses were blank or ambiguous. Two students claimed they could only respond verbally. Two did not know what current intensity is.

c) COMMENTS

Fourteen students recalled the textbook definition to explain electric current intensity in Portuguese, of whom three were able to define correctly what electric current intensity is in Choape. Three of them gave consistent responses in both languages (Q-M) - "quantity of electric charge that flows per unit time" (Portuguese) and the equivalent in Choape: "Intsenko kumbe imphimowa guezi yi phindago kutshi kati tcho kari".

Ten responses (5 Q-"-"; 4 O-"-"; 1 M-"-") used the expression *intensidade da corrente electrica* when responding in Choape, suggesting that the concept "electric current intensity" is unusual or nonexistent in the vocabulary of Choape speakers. Five students (Q-I) were not able to give a Choape equivalent of "current flowing or passing through..." but used the word *intamo* to express "value", "amount", "quantity", "power" according to the specific context. Four students that left the answer blank in Choape gave vague and ambiguous responses in Portuguese.

4.3.3. QUESTION 6 (Insulator) (TABLE 4.3.3 of APPENDIX 2)

Students gave only ONE main idea about INSULATORS when responding in Portuguese:

H: Insulator is an instrument that hinders/obstructs the passage of electric current.

In Choze students also gave the SAME idea:

P: *Insulator njimaha tchi phalelako guezi* (Insulator is an instrument/apparatus that hinders/obstructs the passage of electric current).

DISCUSSION

a) Responses in Portuguese

Seventeen students understood an insulator as a substance or object that blocks/obstructs electric current or does not conduct electricity:

C15: P: *Um isolador é um dispositivo que serve para impedir a passagem da corrente eléctrica*

E: An insulator is a gadget which it is used to block/impede the passage of electric current

C25: P: *Um isolador é uma substância or objecto que não permite a passagem da corrente ou que não conduz a corrente eléctrica*

E: An insulator is a substance or object that obstructs electric current, or does not conduct an electric current

C18: P: *Um isolador é um instrumento que faz com que a corrente eléctrica não passe dum lado para o outro*

E: An insulator is an instrument that blocks/hinders the passage of electric current from one side to another

Eight students gave different and varying explanations.

Some gave unpredictable ideas (C8) or ambiguous answers (C3):

C8: P: *Um isolador é uma peça para isolar um circuito eléctrico que possui carga incluindo equipamento envolvido*

E: An insulator is a piece used to insulate an electric circuit that has charge including involved equipment

C3: P: *Um isolador é um conductor eléctrico que não deixa passar a electricidade de um lado para o outro ou é algo que impede a passagem de qualquer coisa*

E: An insulator is an electric conductor which obstructs the passage of electricity/electric current from a side to another side or is something that blocks the passage of anything

Only one student claimed not knowing what an insulator is.

b) Responses in Choze

Eight students defined an insulator as an instrument or apparatus that hinders/impedes the passage of electric current:

C4: Ch: isolador njimaha tchi thumelako kuphalela guezi
E: Insulator is something used to hinder electric current or
electricity

(The correct word should be *kuphala* instead of *kuphalela*: *kuphalela* means "to hinder" while *kuphala* is to "block" or "shut", although in some Choze dialects *kuphalela* does mean shutting or locking, which is acceptable).

Four students claimed they knew what an insulator was, but could only respond orally. Four gave varied responses, nine left the answer blank, and two claimed no idea what an insulator is.

c) COMMENTS

Nine students gave consistent responses in Portuguese and Choze (1 D-D; 8 H-P). Ten (6 H-"-"; 3 O-"-"; 1 H-D) left responses blank or claimed no idea of what an insulator is in Choze, but answered in Portuguese. This suggests they worked independently in the two languages, i.e. they prefer to explain in Portuguese, and leave the responses blank in Choze, rather than to try to translate from Portuguese to Choze.

Students have a vague idea that insulators are used to block/hinder/obstruct/impede electric current. However nobody defined an insulator via its electrical resistivity, or explained why a material is an insulator, or why it does not readily conduct electric current. Seventeen students gave the same unacceptable Portuguese explanation based on the ordinary meaning of "insulate" as not being in contact with the environment. Eleven left the response blank or claimed no knowledge of insulators (6 H-"-"; 3 O-"-"; 1 H-D; 1 D-D (in Choze)).

In Choze there is no word for resistivity (or any equivalent), so they could not use this idea in Choze explanations. But they did not use the idea in Portuguese either. This may suggest that the non-existence of a scientific word in Choze hinders students in their explaining of scientific terms and their understanding of concepts.

4.3.4. QUESTION 8 (Electric Power) (TABLE 4.3.4 of APPENDIX 2)

Students gave THREE ideas about ELECTRIC POWER in Portuguese:

- T: Trabalho produzido por electricidade num determinado tempo (Power is work produced by electricity per unit time);
- F: Força da energia eléctrica (Force of electric energy);
- C: Capacidade de produzir energia (Capacity of producing energy).

In Choje they gave only ONE main idea:

- I: *Intamo wa guezí* (Electric force or force of electricity).

DISCUSSION

a) Responses in Portuguese

Nine students recalled the textbook definition of electric power:

- C16: P: *Potência eléctrica é o trabalho produzido pela electricidade por (num) determinado tempo*
- E: Electric power is the work produced/done by electricity per unit time

Six students defined electric power as electric force or force of electric energy. Four understood electric power as the capacity to produce energy:

- C26: P: *Potência eléctrica é a capacidade de produzir energia*
- E: Electric power is the capacity/ability to produce energy

Some students gave two ideas (F-C) (in Portuguese) about how they understand electric power. e.g.:

- C23: P: *Potência eléctrica é a capacidade que um corpo possui de produzir corrente eléctrica. Por exemplo um gerador electrico, ou potência eléctrica é a capacidade de realizar trabalho*
- E: Electric power is the capacity which an object has to produce electric current For example an electric generator, or electric power is electric capacity to realise/do work

Eight students showed different perceptions:

- C1: P: *Potência eléctrica é o poder da electricidade ou energia*
- E: Electric power is the force/power of electricity
- C25: P: *Potência eléctrica é a quantidade da energia eléctrica*
- E: Electric power is quantity of electric energy
- C4: P: *Potência eléctrica é o lugar onde sai a energia e começa a distribuição*
- E: Electric power is the place in which the energy goes out and starts to be shared

Some students ("O") gave unpredictable or vague responses (What is the meaning of response C4: power is the place?)

b) Responses in Chope

Ten students understood electric power as electric force (*intamo wa guezi*). Four claimed they could only give a verbal response. Eight were classified as "0", of whom seven left the answer blank. Two claimed no idea about what electric power is.

c) COMMENTS

Students have only a vague idea what electric power is in both languages. They have difficulty in explaining the concept.

In Chope, the concept power should be expressed as nhala meaning to "be able to do the same thing in a short time" or "to be persistent in".

However, many Chope speakers use the word *intamo* (force) instead of *nhala* (power). They use *intamo* to explain for how long someone is able to do something, or how quickly they are able to do this. The word *nhala* is used often in comparative situations: *adi nhala* (has power) refers to:

- the ability to do the same thing but more quickly (i.e. in a shorter time), or
- persistence in wanting to do something.

Unfortunately Chope speakers often use the concept *force* in both ways without looking at the time but looking only the thing done. This social fact hinders students in differentiating the concepts *intamo* and *nhala*.

Students' responses suggest that if their ideas in Chope are deficient or inconsistent, then the same applies in Portuguese.

Nine students left the responses blank, or have no idea in Chope what electric power is, but answered in Portuguese, (only three correctly). Four gave scientifically unacceptable but internally acceptable explanations (2 C-"-"; 1 C-D; 1 F-D).

Four students gave consistent responses (F-I) in both languages: force of electric energy (Portuguese) and *intamo wa guezi* (electric force or force of electricity) in Chope. Five students gave inconsistent answers (T-I) between languages: work produced by electricity (Portuguese) as opposed to *intamo wa guezi* (Chope).

The influence of social factors was present in some cases. Student C22 used as an example an electric generator. It is

common to explain the difference between two electric generators through the brightness of bulbs or the number of consumers that each generator supplies. He also defined electric power as energy.

4.3.5. QUESTION 9 (Conventional current) (TABLE 4.3.5 of APPENDIX 2)

Students gave TWO main ideas about CONVENTIONAL CURRENT in Portuguese:

- P: *Corrente convencional é o movimento das cargas eléctricas do polo positivo para o polo negativo* (Conventional current is motion of electric charge from positive pole to negative pole);
C: *Convenção é um acordo* (Convention is agreement).

In Chope they gave TWO main ideas:

- T: *Ku tsimbila ko hambana ka guezi in dane kati koti ta guezi* (Conventional current is an opposite motion to the real flowing of electric charge through an electric conductor);
L: *Corrente convencional yi guezi yo langana/yo inguitsana* (Conventional current is current in agreement).

DISCUSSION

a) Responses in Portuguese

Six students understood conventional current as a current flowing or moving from a point at a positive potential to a point at a negative potential. Some responses were:

- C2: P: *Corrente convencional é aquela que sai de um polo positivo para o polo negativo*
E: Conventional current is that which goes from the positive pole to the negative pole
C11: P: *Corrente convencional é o movimento não real dos electrões*
E: Conventional current is not the real motion of electrons

Six students explained the meaning "conventional" as something predetermined. For C21 conventional current is "adjusted or previously determined electric current" while C13 described conventional current is a "continuous motion of charges following a way previously determined":

Four "O" students gave unacceptable responses such as:

- C9: P: *Corrente convencional é uma forma de energia que é convertida em outra, logo dizemos que essa corrente foi convertida*

- E: conventional current is a form of energy which is converted to another, and we say this is converted current
- C1: P: Corrente convencional e corrente previamente combinada
E: Conventional current is combined current
- C18: P: Corrente convencional e corrente calculada
E: Conventional current is calculated current

The reasoning behind the underlined terms can only be speculated.

b) *Responses in Choqe*

Two students recalled textbook answers to explain conventional current, although their answers imply that the real flow of electrons in the typical electric conductor is known:

- C17: Ch: Conventional current ku tsimbila ko hambana ka guezi
E: Conventional current is opposite flowing of electric current or electricity

Three students claimed they could only explain orally. Seven were grouped in the column "L" of whom three gave the meaning of the word "convention" without relating it to electricity or electric current, but to the ordinary meaning only:

- C1: Ch: Corrente convencional yi Guezi yo langana
E: Conventional current is agreement/combined electric current

C1 asserted that he used his knowledge in Portuguese to try to explain conventional current, because for him this expression is usual in Choqe. Unfortunately his understanding even in Portuguese was not clear or scientifically acceptable.

It is uncertain whether students' understanding of conventional current as "agreement current" relates to the motion/flowing of charge or electrons, or not.

Three students left the responses blank. Seven claimed no knowledge about conventional current.

c) COMMENTS

Of 28 students, 9 answered neither in Portuguese nor in Choqe. Of the remainder ten did not answer in Choqe. Only four gave an adequate response in Choqe, while six did the same in Portuguese. Only two students seemed to consistently understand conventional current in both Portuguese and Choqe.

Three students claimed they were able to respond only orally in Choqe, and only two gave a correct answer in Portuguese. We conclude that students found the concept difficult to understand.

4.3.6. QUESTION 10 (Electric Circuit) (TABLE 4.3 6 of APPENDIX 2)

Students gave TWO main ideas about an ELECTRIC CIRCUIT in Portuguese:

- C: Circuito eléctrico é um conjunto de elementos electricos (Electric circuit is a conjunction or connection of electric elements);
P: Percurso feito pela corrente eléctrica (Electric circuit is path of electric current).

In Chope they also gave TWO main ideas:

- T: Electric circuit ngu tsangana kumbe ku lunghalhatelana ka sigotso tsa guezzi (Electric circuit is an association or connection of electric elements);
N: An electric circuit ndzila ya guezzi (Electric circuit is a path of electric current).

DISCUSSION

a) Responses in Portuguese

Twelve students understand an electric circuit as an association or combination of electric components:

- C17: P: Um circuito eléctrico é uma associação de fios eléctricos ligados aos polos ou terminais de um gerador
E: An electric circuit is an association of electric elements connected through wires from the poles or terminals of a generator
C2: P: Um circuito eléctrico é um sistema constituído de uma fonte de tensão que fornece a corrente (eléctrica) a um conjunto de consumidores
E: An electric circuit is a system constituted by a source of tension which supplies a(n) (electrical) current for joined consumers

C2 shows a common misunderstanding, i.e. that the source of electromotive force ("tension") is a source of electric current (rather than an energy source).

Three students understood an electric circuit as a path or route taken by electric current:

- C19: P: Um circuito eléctrico é o caminho percorrido pela electricidade
E: An electric circuit is a path done by electricity

Six students showed different and ambiguous ideas:

- C1: P: Um circuito eléctrico é o trajecto exercido pela corrente eléctrica or simplesmente é um campo eléctrico
E: Electric circuit is path/course of electric current or equitable/just path

Others responses grouped in column "0" suggest that students have some ideas about electric circuits, relating to personal experience, but which are scientifically unacceptable:

- C12: P: Um circuito eléctrico é a linha que transporta a corrente eléctrica
 E: An electric circuit is a line which transports electric circuit
- C23: P: Um circuito electrico é um material que serve para distribuir regularmente ou quando é necessario a quantidade the energia
 E: An electric circuit is a material which serves to distribute regularly a necessary quantity of energy

Some students took energy to relate only to electricity or electric current. For them an electric connection or installation in the house or classroom IS an electric circuit (not an *component* of an electric circuit), or it is a device that serves to distribute energy, e.g. through different rooms.

b) Responses in Chope

Six students understood an electric circuit as an attachment or association of electric elements connected with electric wire:

- C13: Ch: (Electric circuit) kuphatana ka tchissima tcha indilo wa guezi ti waielas di tsimuhane sigotso tsa guezi
 E: Electric circuit is a association of source of tension or potential difference, wire and other electric elements

For other students, e.g. C10 and C17, an electric circuit is a path of electric current or electricity.

- C10: Ch: (Electric circuit) ndzila ya guezi or ku mu wa yi simbilako inkona guezi
 E: Electric circuit is the path or route of electricity or electric current

Three students were not able to answer in writing, although they could explain what an electric circuit is in Chope. Two students showed different understandings, e.g.

- C21: P: Muchine waku caregara mabateria diko tchaia marado nity fio takona
 E: Electric circuit is an apparatus/instrument used to load charge in cells/battery and play a radio

(Again these responses show that the source of students' knowledge may be determined by local factors at home or the job)

c) COMMENTS

Many students have some idea what an electric circuit is. This fact is shown in both Chope and Portuguese. Twenty-one students answered the question. Many responses were categorised as "T" and "N" in Chope and "C" and "P" in Portuguese. Four/three left the answer blank in Chope/Portuguese.

Ideas "C" and "T" recall textbook definitions, while ideas "P" and "N" are based in everyday social usage.

4.3.7. QUESTION 12 (Electric Current) (TABLE 4.3.7 of APPENDIX 2)

Students gave TWO main ideas about ELECTRIC CURRENT in Portuguese:

- F: An electric current is a motion of electrons in one way, or a flowing of electrons;
M: An electric current is a motion of electric charge.

In Chope they also gave two main ideas:

- I: *Electric current insinga wa guezí* (Electric current is motion of electricity (charges) in one direction [*insinga* denotes flowing of water in one direction]);
N: *Electric current ndilo wa guezí* (is fire of electricity).

DISCUSSION

a) Responses in Portuguese

Some students understood electric current as the result of the motion of electrons in one way - flowing from low to high potential:

- C7: P: *Corrente eléctrica é um movimento ordenado de electrões do menor potencial para o maior potencial*
E: Electric current is an ordered motion of electrons from low potential to high potential

These responses are scientifically correct as long as students understand that the electron has a NEGATIVE charge (conventional positive charge moves from high potential to low potential). For another 10 students, (e.g. C4, C5), electric current is a motion of charged (electric) particles between two points at different potentials:

- C5: P: *Corrente eléctrica é fluxo unidirecional de electrões que se cria quando certo circuito é uma vez submetido a uma diferença de potencial*
E: Electric current is unidirectional electron flow when a electric circuit is submitted a potential difference in

Five students understood an electric current as a motion of electric charge:

- C25: Ch: *Corrente eléctrica é movimento de electrões*
E: Electric current is motion of electrons
C2: P: *Corrente eléctrica é o movimento continuo de electrões livres*
E: Electric current is continuous motion of free electrons

These responses are ambiguous. They are imprecise about the kind of motion that the electrons / electric charge have. This motion could be chaotic or unidirectional.

Some students understood electric current in other ways. For example: e.g. C3: electric current is "orientational" motion of charge; C14: electric current is force that energy needs to realise various/any activities!!

Answers grouped as "O" are vague, ambiguous or unqualifiable (e.g. C3). Some responses suggest that the source of some knowledge is the ordinary environment:

C1: P: Corrente eléctrica é a corrente fornecida num determinado estabelecimento
E: Electric current is a current that is supplied to a establishment/shop

For many students the concept of energy is a synonym for electricity or electric current.

b) Responses in Chope

Six students said that electric current is *insiga wa guezi* (motion of electricity in one way) or just *guezi*:

C17: P: Corrente eléctrica insiga wa guezi
E: Electric current is flow of electric charge

Seven students understood electric current as *indilo wa guezi* (fire of electric current/electricity). Seven answers were grouped in the column "O":

C1: Ch: Corrente eléctrica indilo wuhumiswako ngu diwinji kumbe intchini wa guezi ni simuane simaha sa guezi
E: Electric current is electric fire from a generator and other electric elements

c) COMMENTS

Ten students showed a good understanding of electric current in Portuguese. Three understood that electric current is an ordered motion of electrons, but could not account for the cause of the motion. Five related electric current with the motion of electric charge, but could not explain the kind of motion.

Again ideas such as *indilo wa guezi* to characterise electric current showed that local factors are a main source of knowledge.

Explanations in Chope show that students know about electric current through its utility, e.g. for cooking, lighting bulbs, ironing clothes, etc. This understanding does not give any information about the motion of charged particles.

Some responses suggested that students ideas in Chope might be useful as a foundation to acquire new knowledge and scientific ideas. Three students gave consistent answers across languages

when they explained electric current (F-I).

4.3.8. QUESTION 14 (Parallel electric circuit) (TABLE 4.3.8 of APPENDIX 2)

Students gave only ONE main idea about a PARALLEL ELECTRIC CIRCUIT (PEC) in Portuguese:

R: A PEC is/are electric elements associated/connected in the electric circuit, where all of them receive the same potential difference across their ends.

In Choqe NO MAIN IDEA emerged.

DISCUSSION

a) Responses in Portuguese

Three students understood the PEC as an association or connection of electric elements, where the circuit supplies the same potential difference (tension). Eight showed other ideas:

- C1/6: P: Circuito eléctrico em paralelo (CEP) é trajecto em dois sentidos ou linhas que não se cruzam
E: PEC is a path of electricity in two directions, or lines which never have a common point (do not intersect)

Such responses are influenced by the mathematical definition of "parallel".

a) Responses in Choqe

Thirteen students said they had no idea about the PEC. Three claimed they could only answer orally; two gave vague and different ideas; two left the response blank.

c) COMMENTS

Students' responses showed that the concept was strange to them.

Some (e.g. C1 as above) showed in the influence of the mathematical definition of "parallel". However most knew a PEC as some association of electric elements, although most do not know how these electric elements are associated:

- C14: P: CEP é aquele circuito em que intensidade circula em cada lampada
E: PEC is a circuit, in which the intensity flows through each bulb
- C9: P: CEP é um circuito em que várias fontes de energia podem ser ligadas por um único interruptor
E: PEC is a circuit in which various sources of energy can be connected by one switch
- C11: P: CEP é onde existe uma font, um amperimetro, interruptor. É onde entra e sai corrente

E: PEC is where there exists a source, an ammeter, a switch. It is where the current goes in and out

In Chope too a PEC is an association of electric elements:

C17: Ch: (PEC) intihangano wa tingoti ta guezzi to sungana ngu inlhawa
E: PEC is union/joint of electric wire, all of them connected

C18: Ch: Sigotso tsa guezzi so longoloka
E: Electric elements connected in sequence

The answer from C18 is not clear. The word *longoloka* could address more than one meaning, such as: (a) electric elements are in series, or (b) electric elements are connected side by side (similar to mathematical parallelism).

Some students did not have any idea about the PEC or left the response blank in Chope, but answered ambiguously in Portuguese:

C2: P: Circuito electrico em paralelo (CEP) é onde exist voltmetro, amperimetro, resistencia, tudo
E: PEC is where there exists voltmeter, ammeter, resistance, everything

4.3.9. QUESTION 16 (Potential Difference (pd)) (TABLE 4.3.9 of APPENDIX 2)

Students gave only ONE main idea about POTENTIAL DIFFERENCE (pd) (voltage or tension) in Portuguese:

E: (PD) is the difference in energy between two points.

In Chope they gave two main ideas:

G: (PD) kuhambana ka intamo wa guezzi (PD is the difference of electric force or force of electricity);

M: (PD) kuhambana ka matsimbilelo ya guezzi (pd is the difference in/of how the electricity or electric current is flowing)

DISCUSSION

a) Responses in Portuguese

Eight students understood pd as the difference of energy between electric charges flowing between two different points:

C11: P: Diferença de potencial é a diferença de energias das carga que se movem entre dois extremos

E: PD is the difference of energy of charges moving/flowing between two extremes

C5: P: Diferença de potencial é a diferença das energias que se verifica entre dois pontos de um circuito em relação a terra ou entre dois pontos de um campo eléctrico

E: PD is the difference of energies between two points of a circuit in relation to the earth or between two points of an electric field

Some responses ("O") gave differing perceptions:

C1: P: *Diferença de potencial é o inverso do circuito paralelo*
E: PD is the inverse/opposite of a parallel circuit

b) *Responses in Chope*

Three students understood pd as *kuhambana ka intamo wa guezzi* (the difference in electric force/energy):

C17: Ch: *(PD) kuhambana ka mitano ya guezzi indane ka sigotso sa guez, kuphana dilokouo tchorra indilo niketcheni, loko udi hanithimbane kumbe hafuyi di txiku*
E: PD is the difference of electric force/energy into electric element, like if you are using hater??. near to hater or far near of door

One student understood pd as *kuhambana ka matsimbilelo ya guezzi indane ka mawaiela ya guezzi* which means

- the difference of motion of electric charge or electric current into an electric wire, OR
- how differently the electric current flows into an electric wire.

c) COMMENTS

Responses suggest that the concept of pd is uncommon in Chope, and strange for many students. Most will have encountered it only at school. Nonetheless eight students understood the concept well in Portuguese as - e.g. C23: *PD is the work done per unit charge when moved/displaced between two point by any path.*

Some students' weakness in Portuguese may relate to (mis)understandings in Chope - e.g. C1 understood in Portuguese that PD is *the inverse or opposite of* because for him difference means different/inverse/not equal. The student may be trying to understand word-by-word without relating the question to electricity.

Another problem in this question is related to translation. Some students do not translate the content, but translate the words, so missing the "whole" message. This may apply to translation from Portuguese to Chope and v.v..

4.3.10. Q17 (Source of electromotive force (EMF))
(TABLE 4.3.10 of APPENDIX 2)

Students gave only ONE main idea about EMF in Portuguese:
G: EMF is a generator of electric current.

When responding in Choze they also gave ONE main idea
T: EMF *tchissima/ndjisima tcha guezi kumbe ikadi yo bika indilo* (EMF is the well of electricity electric current).

DISCUSSION

a) Responses in Portuguese

Nine students understand EMF as a generator or a well of electric current. Some responses are:

C13: P: Fonte da força electromotriz é um gerador
E: EMF is a generator

C15: P: Fonte da força electromotriz é um poço da corrente eléctrica
E: EMF is an electric well

These responses are imprecise or unclear if students are intended to understand EMF as a component of an electric circuit which does work moving electric charges round the circuit. Students' responses do not suggest that the EMF is a source of energy for electrons. Three students said they had no idea about EMF. Six students stated different perceptions about EMF:

C16: P: (EMF) é a intensidade da corrente, é quantidade de electricidade induzida
E: EMF is current intensity, is the quantity of induced electricity

The above misunderstanding is common among students. They see EMF as an induced current, rather than as a primary source of energy from which current results. Other unqualifiable responses were:

C12: P: (EMF) é rio
E: EMF is a river

C2: P: (EMF) é a força de um motor
E: EMF is a force of an engine

(What is meant by an engine - is it the same as a generator? In ordinary social life a generator it is called an engine/motor)

b) Responses in Choze

Seven students understand EMF as a well/warehouse of electricity or as a source/generator of electricity. For example for:

C1: Ch: (EMF) diwinji ni humisako guezi.
E: EMF is a generator which supplies electricity

C13: Ch: (EMF) tchissima/ndjisima tcha guezi
E: EMF is a wall of electricity

C13 attached a local understanding about the "font/source" of electromotive force: because he does not know the real word for EMF, he nonetheless thinks he has used an equivalent expression to describe the concept in Choze.

Five students asserted they had no idea about EMF. Six claimed they could give an oral response. Two left the response blank.

c) COMMENTS

Five students gave consistent answers across languages (G-T). For them EMF is a generator (Portuguese) and ndjisima/diwinji tcha guezi (well/source of electricity) (Choze). Five students have no idea about EMF in Choze, against three in Portuguese.

If the responses (G-S) indicate that students know what EMF is in Choze, and we cluster these with responses "T", then the number of the students that might give an acceptable answer about EMF in Choze rises to ten students, against nine in Portuguese. So although responses are different in appearance, the number of students that give the same idea are roughly equal in Choze and Portuguese.

Responses (2 O-D, 2 O-S, 1 O--", 1 O-T) suggest that students may prefer to guess a response in Portuguese than to claim they do not know. Many responses coded as "O" are unqualifiable and/or vague, such as EMF is electric current (C25) EMF is electromotive force (C18). However some responses, such as EMF is a river or well may originate from social influence: an EMF as a source of supply of electricity to light a bulb or play a radio, is like a river or well to supply water (in rural areas) particularly. Again we must recognise the social environment as a principal source of knowledge.

4.3.7. GENERAL ANALYSIS OF BASIC CONCEPTS OF DC CIRCUITS (Qs 3, 4, 6, 8, 9, 10, 12, 14, 16, 17)

The preceding analysis showed that for some concepts (conventional current (Q9), parallel electric circuit (Q14), potential difference (Q16) and source of electromotive force (Q17)), students found such great difficulties that they often did not respond, which makes it difficult to probe their true understanding of these concepts. For other concepts (electric resistance (Q3), current intensity (Q4), an insulator (Q6), electric power (Q8)), many students were willing to offer any explanation about the concepts.

Students' responses were coded and summarised in TABLE 4.3.11.1 and TABLE 4.3.11.2 on page 61.

Responses showed that for concepts common to everyday language/life, students explained in their own words, in a way that clarified their meanings. These were sometimes acceptable scientifically, but more often than not they were only internally consistent.

Resistances and insulators

In Q6, 17 students out of 26 understood an insulator as an object or substance which blocks/obstructs electric current. Students were not able to differentiate between the words "substance" and "object". We attribute this to poor performance in Portuguese. Another problem was that students did not relate an insulator with high electric resistivity. The concept of resistivity is a scientific term that is used only in specific contexts or in the physics classroom. Students used explanations or analogies from their local environment to get round these difficulties.

Circuit

In Q10, 15 students understood an electric circuit as a connection of electric elements through electric wires or as a path of electricity. Students do not realise that a circuit is related with a closed system, where the law of conservation of energy applies. It was also evident that weakness in Portuguese did not allow students to properly understand the meaning of the word "circuit". Due to local factors students attached meanings

TABLE 4.3.11.1: Summary - Basic concepts of DC circuit (Chope)

Students' responses in Chope										
Code	Questions									
	Q3	Q4	Q6	Q8	Q9	Q10	Q12	Q14	Q16	Q17
E	6	0	0	10	2	0	0	0	0	7
G	5	4	8	0	0	9	6	0	3	0
M	0	7	0	10	2	0	7	0	0	7
W	4	2	4	1	6	2	2	2	1	0
D	1	2	2	2	7	4	3	13	9	5
B	7	9	9	7	4	4	5	2	3	6
S	3	2	4	4	3	3	4	3	3	2

Code

- E: Student gave unacceptable "definitions" or expressions influenced by local factors
- G: Student did a good translation into Chope, and showed good understandings in Chope. His/her understandings are scientifically acceptable, and can be understood by any Chope speaker
- M: Student used general definitions without any explanation
- W: Student gave incorrect response
- D: Student claimed no idea what the concept is
- B: Student left the response blank
- S: Student claimed his/her can only respond orally

TABLE 4.3.11.2: Summary - Basic concepts of DC circuit (Portuguese)

Students' responses in Portuguese										
Code	Questions									
	Q3	Q4	Q6	Q8	Q9	Q10	Q12	Q14	Q16	Q17
R	0	14	0	9	6	0	0	3	8	0
A	0	0	17	0	0	15	10	0	0	0
E	15	0	0	6	6	15	5	0	0	9
W	23	11	8	14	10	6	8	8	5	6
D	0	1	1	0	3	0	0	6	6	3
B	1	0	0	0	0	1	4	3	0	2

Code

- R: Student recalled textbook definition to explain his/her understanding about the concept;
- A: Student gave acceptable definition in his/her own words;
- E: Student gave unacceptable definitions or expressions influenced by local factors;
- W: Student gave incorrect response
- D: Student claimed no idea what the concept is
- B: Student left the response blank

electric resistance (Q3), electric current intensity (Q4), insulator (Q6), electric power (Q8), conventional current (9), an electric circuit (10), electric current (12), parallel electric circuit (14), potential difference (16) and source of electromotive force (Q17)

such as circuits for traffic or cars; circuits in the political sense; circuits as a path or corridor.

Multi-word concepts

In questions such as Q4, Q8, Q14 (in which the basic concepts are not used in students' ordinary vocabulary/environment) we find that a great number of students recall textbook definitions to explain their understanding: However problems then arise. Concepts such as conventional current, potential difference, parallel electric circuit, electric resistance, electric power and source of electromotive force are constituted by words that are also used in ordinary language, or can be found in science but associated with other meanings. This hinders students' perceptions of the meaning of the expression as an electrical concept.

- For instance the word "conventional" is related to the common meaning "agreement": conventional current is then seen as just a current in agreement.
- A parallel electric circuit (Q14) is described as a circuit "without a common point". Here the "interference" derives from the mathematical definition of the concept "parallel", so that the word parallel stimulates in students' minds the notion of "without intersection".

Numerous difficulties in understanding scientific concepts defined by more than one word were found throughout our analysis of electric concepts. If a student chooses a word as a "key" word and his perception of this word is incorrect, then automatically his perception about the whole concept becomes erroneous.

Responses in Choqe

Students prefer to use their own words to explain their understandings; or they use a common/ordinary definition in Choqe. This was evident for concepts common to the students' life (such as electric resistance (Q3), an insulator (Q6), electric circuit (Q10), electric current (Q12)). Many students showed a good understanding in Choqe and they gave scientifically acceptable explanations too. In Q10, nine students explained an

electric circuit as *ngu lunganhete lua kumbe kupathanhitsua kasy ngotso sa maguezi sopfana di tiwaiela ta guezi, malapada, niwindje nitsi muane* (it is an association of a source of tension, an electric wire, and other electric elements).

For concepts used only in schools or in a specialised context (so uncommon in ordinary vocabulary), such as conventional current (Q9), electric power (Q8), parallel electric circuit (Q14), students have little idea what these concepts are.

It is evident that local factors (e.g. linguistic, habit) had a strong influence on students' understanding.

- For instance in Q8, 10 students understood electric power as *intamo wa guezi*, and a similar response was given in Q4, because in Choze concepts such as force, energy and power are defined as an interaction (but electric current is recognised through its utility).
- Explanations about a source of EMF were based on analogy. Students understood EMF as a "well of electricity". (They understand EMF as a source of electricity rather than a source of energy [a common misunderstanding]).
- In Q12 too students used analogy to define electric current, understood by many as *insiga wa guezi*. Many had grown up near the Indian ocean or a river. The word *insiga* (current) is then well known to students who then use it to define electric current scientifically (*insiga* means motion in one direction).

Miscellaneous comments

Responses showed that:

- If students have a good understanding about a concept in Choze, and this prior knowledge is scientifically acceptable, then they are able to easily acquire the same concept in Portuguese (e.g. Q4, Q6, Q10, Q12). However if ideas are incorrect in Choze (i.e. develop misunderstandings) then students will not easily acquire correct scientific ideas in Portuguese about these concepts (e.g. Q9, Q14).
- * If we combine Choze students coded by "D" (no idea) together with students coded by "B" (blank), and also consider in Portuguese students coded by "W"

(incorrect) we find that for concepts such as Q4, Q6, Q8, Q9, Q10, Q12 the number of students that prefer to leave the responses blank in Chope is the same of the number of students that prefer to guess (to give incorrect responses) responses in Portuguese.

● We suggest that:

- Students prefer to state their real understanding (in Chope) rather than to try to guess or to "invent" the meaning of any basic concept of DC circuits in Chope.

OR

- Students worked independently between both languages and avoid trying to translate their understanding from Portuguese to Chope.

- In questions such as Q3, Q4, Q8, no one responded by using equations. This suggests that students had no concept of an equation in mind.
- Responses showed that common words with different meanings in different subjects, or with different meanings in science and ordinary life, hinder students' perceptions when learning science (e.g. Q3, Q14)
- Some students exemplified a language degradation: where the "new" generation of learners loses or misses the traditional vocabulary of the mother tongue. For instance nobody used the word *nhala* as equivalent of the word power, and only two students used the word *tchikotchicane* instead of *tchicarrinhana*. Nevertheless students spoke and wrote "current Chope" reasonably well.

4.4. CIRCUIT COMPONENTS AND INSTRUMENTS

(Questions 2, 5, 15, 18)

4.4.1. QUESTION 2 (Voltmeter) (TABLE 4.4.1 of APPENDIX 2)

Students gave TWO main ideas about a VOLTMETER when responding in Portuguese:

V: Measures tension, voltage or potential difference (equivalent of words *tensão*, *voltagem* and *diferença de potencial* in Portuguese);

A: Measures current intensity.

In Chope they gave only ONE main idea:

M: *Mutchini uo thepa Intamo wa guezzi* (apparatus used to measure electric force).

DISCUSSION

a) Responses in Portuguese

Fifteen students out of 28 were able to recognise the function of a voltmeter:

C7: P: Voltímetro é um instrumento que serve para medir a tensão
E: Voltmeter is an instrument which is used to measure the tension

Some students do not know how to connect a voltmeter:

C6: P: Voltímetro é o aparelho que serve para medir a diferença de potencial entre dois pontos. Para se medir a voltagem deve se colocar o voltímetro em serie
E: Voltmeter is the apparatus/equipment used to measure potential difference between two ends. To measure a voltage the voltmeter must be connected in series (1)

For eight students a voltmeter measures current intensity:

C20: P: Um voltímetro é um instrumento que serve para fazer registo da corrente eléctrica que entra na resistência
E: A voltmeter is an instrument/apparatus used to register the electric current that goes into a resistance

Other students presented explanations scientifically unacceptable or ambiguous:

C23: P: Voltímetro é um métro com que se mede uma das formas de energia
E: Voltmeter is a meter which measures a form of energy

C3: P: Voltímetro é um aparelho que serve para medir o volt
E: Voltmeter is an apparatus/equipment used to measure the volt

b) Responses in Chope

Nine students understood a voltmeter as an instrument used to measure electric force:

C10: Ch: Voltímetro mutchini uo thepa in tamo wa maguezi
E: Voltmeter is a apparatus or instrument used to measure electric force (or force of electric current)

Seven students claimed they have no idea what a voltmeter is.

- C21: Ch: Kani kali kupfa intu a tohi muamuatha ku voltmetro, kumbe ku dana voltmetro ku tchitchopi.
E: I never listen to anyone talk about a voltmeter or to "call voltmeter" in Chope

Five students claimed they were only able to respond verbally.

c) COMMENTS

Responses showed that:

- i) When some students wrote/talked about a voltmeter in Chope, they used the word voltmeter, although they translated words like force, electricity and electric current. This suggests that students are able to translate some scientific terms but not others.

OR

- ii) Chope has equivalent expressions/words for some scientific concepts but not for others: in particular, it does not have an equivalent word for voltmeter.

We suggest that students left responses blank because they do not know what to call a voltmeter in Chope (four left the answer blank in Chope, while all could answer in Portuguese).

Nine students were consistent in their use of Portuguese and Chope, (V-M and V-I). They understood the concept in the same way in both languages. For six students a voltmeter is an instrument used to measure tension (Portuguese) and mutchini uo thepa intamo wa guezi (Chope), while for another two students a voltmeter measures current intensity (Portuguese) and mutchini uo thepa intamo wa guezi (Chope), where responses (V-M) are scientifically acceptable while (V-I) are only acceptable internally. The multi-meaning of the words intamo and guezi in Chope causes students to use the term intamo wa guezi (force of electricity or force of electric current) to express voltage OR current intensity.

4.4.2. QUESTION 5 (Interrupter) (TABLE 4.4.2 of APPENDIX 2)

Students gave TWO main ideas about an INTERRUPTER when responding in Portuguese:

- I: An interrupter is an instrument used to open or close an electric circuit;
- B: An interrupter is an instrument used to switch on or switch off bulbs.

In Chope they gave only ONE main idea:

- L: Njimaha tchi tumelako ku laitha guezi/dilampada (something/instrument used to switch bulbs on or off).

DISCUSSION

a) Responses in Portuguese

Three students recalled textbook explanations about interrupters. For student C19 it is an instrument used to OPEN or CLOSE an electric circuit. Twenty-one students understand it as an instrument used to switch a bulb ON or OFF:

- C12: P: Um interruptor é um dispositivo que é utilizado para acender/ligar or apagar (desligar) a luz
E: An interrupter is an instrument used to switch a light/bulb on or off

Three students gave different responses. Some are vague (e.g. for C3, an interrupter is used to open or to close [What is opened or closed is not mentioned]).

b) Responses in Chope

Thirteen students understood an interrupter as used to switch bulbs on/off. Five were only able to give oral responses. Three claimed they had no idea what an interrupter is.

c) COMMENTS

Many students see an interrupter as an instrument used to switch bulbs on or off. Ten students understood this the same way in both languages (B-L): In Chope this is expressed as interrupter njimaha tchi thumelako ku laitha/kuthim.

Students' understandings were strongly influenced by prior experience and common usage: switching bulbs on or off in classrooms and houses. This is reinforced by didactic procedures in science classes during the teaching of Ohm's law and resistance: circuits are set up with a source of tension, a bulb and an interrupter. During these experiences the function of

the interrupter is clearly evident: to switch the bulb on or off.

Twenty-one students understood, in Portuguese, that an interrupter switches bulbs on or off, while only 13 understood the same thing in Choqe. This suggests that language is a stimulator for communication: when students think in Choqe the word interrupter does not develop any picture, while the same word in Portuguese seems to do so.

4.4.3. QUESTION 15 (Metal wire) (TABLE 4.4.3 of APPENDIX 2)

Students gave TWO main ideas about a METAL WIRE when responding in Portuguese:

E: A metal wire is an electric conductor;

M: A metal wire is a wire, a rope.

In Choqe TWO ideas were also given:

G: Yi waiela ya guezi ([Metal] wire is an electric conductor);

W: Yi waiela/ngoti kumbe digjocke ([metal] wire is wire or "metal rope").

DISCUSSION

a) Responses in Portuguese

Ten students understood a metal wire as an electric conductor:

C17: P: Um fio metálico é um condutor elétrico

E: A metal wire is an electric conductor

Three students understood a metal wire as wire/rope:

C18: P: Um fio metálico é um arame ou cabo, que pode ser de ferro, aço, etc

E: A metal wire is a wire or rope that could be of iron or steel

Seven students stated different opinions:

C21: P: Um fio metálico e um elemento flexível neste, caso é um elemento que serve para transportar energia

E: Flexible element, in this case an element that serves to transport energy

C24: P: Fio metálico é um material feito a partir de metal

E: Metal wire is a material made of metal

C3: P: Fio é uma fibra extraída de plantas têxteis

E: Metal wire is a fibre tacked up of textile plant

C3 shows interference between scientific language, common Portuguese and Choqe. Some scientific expressions are imported from other languages into Choqe by adding a suffix or prefix. For example: a battery is called nibatária; a lamp is called nilambu. For expressions constituted by more than a word (e.g.

electric current intensity; electric wire, electric current) it is usual to use a "key word" to address the meaning of the concept. If the key word is wrongly addressed the meaning of the word/expression will automatically change too. This is what happened to C3 when he analysed the concept metal wire. For C3 the key word was wire which is yifio in Choze: but he took yifio as a fibre (influence of biology).

b) Responses in Choze

Thirteen students understood a metal wire as a wire or steel rope, not related with electricity:

C4: Ch: *Um fio metálico yi ngoti/waiela ya simbi*
E: A metal wire is an iron or steel wire

C2: Ch: *Um fio metálico digjocke da simbi*
E: A metal wire is a "metal rope", which can be of iron or steel

Nine students related a metal wire with an electric conductor, (e.g. C7, C15 define metal wire as waiela ya guezzi [electric wire or electric conductor]). Five asserted they do not know what a metal wire is. Two claimed they could only respond verbally.

c) COMMENTS

Some responses (E-W, E-G, W-G) suggest that students had a good understanding of a metal wire. However students confused the concepts digjocke (rope) and nghoty (wire) as equivalent concepts (in Choze), because they took a metal wire as something to tie or to make a back yard. They do not see that a metal wire can conduct electricity: they understand a metal wire through prior personal experience and practical utility - something used to tie objects, or used during the construction of houses.

4.4.4. QUESTION 18 (Battery) (TABLE 4.4.4 of APPENDIX 2)

Students gave TWO main ideas about a BATTERY in Portuguese:

A: A battery is a source of electromotive force; it is an accumulator;

K: I know what a battery is, but I do not know how to explain my understanding. A battery is an (electric?) capacitor; a cell; an apparatus used in cars.

In Choze, students gave only ONE main idea:

W: A battery is difeko da guezzi (battery is an accumulator or "warehouse" of electricity/electric current).

DISCUSSION

a) Responses in Portuguese

Eleven students understood a battery as an electric apparatus, able to supply energy, while for other students it is a device which supplies electricity:

C1: P: Uma bateria é um aparelho que fornece electricidade, é mais grande que uma pilha. Uma bateria é uma fonte da força electromotriz (fem) mas não é uma pilha porque uma bateria tem carga, usa a carga depois de descarregada pode ser recarregada, isto é, carregada de novo. Uma bateria é um acumulador
E: A battery is an apparatus, which supplies electricity, and is bigger than a cell. A battery is a source of electromotive force (EMF) but is not a cell, because it has charge which can be used, and after it is discharged, it can be recharged. A battery is an accumulator.

C9: P: Uma bateria é um dispositivo capaz de fornecer energia por isso é usado como fonte de energia nos carros
E: A battery is an apparatus/instrument able to supply energy, and because of that, it is used as a source of energy in cars

Eleven students claimed to know what a battery is, although they have difficulty in explaining their understanding. However most of them then gave in their own words acceptable explanations:

C24: P: Uma bateria é um capacitor usado nos carros, motos, para acender as luzes piscas
E: A battery is a capacitor used in cars and motorbikes for headlights and for indicators to wink

C18: P: Uma bateria é uma partícula eléctrica com uma certa capacidade eléctrica. Uma bateria é usada para tocar radio, gira-discos, é usada também tractores e carros.
E: A battery is an electric particle, with certain electric capacity. A battery is used to play radios, record-players. it is used, too, in tractors and cars.

Five students gave confused responses:

C16: P: Uma bateria é uma forma de energia
E: A battery is a form of energy

C14: P: Uma bateria é uma energia que tem a corrente mas que funciona através de uma carga
E: A battery is a (source of) energy, which has current, but it is working through a charge

b) Responses in Choze

Six students asserted that *nibattery difeko da guezi* (a battery is accumulator or "warehouse" of energy). Two claimed they did not have any idea about what a battery is, while nine students asserted that they did know. Although only able to respond orally, three students give unqualifiable responses, or confused the concept battery with bacteria:

C21: Ch: Uma bateria nibatteria
E: A battery is a battery

C25: P: Uma bateria tchi kalane tchatchinoto nguntu tchaku uongo
tchiouana kumitcini yi danuako taku ma microscopio
E: A battery is a micro-organism, which we can only see through an
instrument called a microscope

c) COMMENTS

Many students know what a battery is in Portuguese. Eleven responses were very similar: a battery is a capacitor; a cell; an accumulator. Six students gave equivalent responses in Chope.

Students' understandings of batteries is strongly influenced by local factors (social knowledge). They know that a battery is used in a car to supply energy, or to play a radio (often in rural area). However they are unable to give a scientifically acceptable explanation of what a battery is.

Again students refer to electricity/electric current as energy. Students do not recognise energy as capacity to do work. C13 and C1 understood a battery as a source of electromotive force (in Portuguese), and the equivalent responses were given by students in Chope (e.g. C4 and C19 understood a battery as *difeko da intamo wa guezi*). But some of these students could not respond or explain what a source of electromotive force is in Question 17 (in both languages)! Others however were able to use the concept of a battery to define what EMF is.

4.4.5. GENERAL COMMENTS ON CIRCUIT COMPONENTS AND INSTRUMENTS (Questions 2, 5, 15, 18)

This sub-group consists of four concepts. Three are common in students' vocabulary (interrupter (Q5), metal wire (Q15), battery (Q18)), while a voltmeter (Q2) is strange for many students.

Students' responses were coded and summarised in TABLES 4.4.5.1 and 4.4.5.2 on page 72.

Responses showed that students recalled textbooks to explain how they understood circuit components and instruments, uncommon in everyday life. For instance 15 students out of 28 understood a voltmeter as an apparatus used to measure voltage (pd/tension), and the same definition was given by nine students when responding in Chope: voltmeter intchini uo thepa intamo wa guezi

TABLE 4.4.5.1: Summary - Circuit components and instruments (Chope)

Code	Students' responses in Chope			
	Questions			
	Q2 A voltmeter	Q5 A switch (interrupter)	Q15 A (metal) wire	Q18 A battery
E	0	13	22	6
G	9	0	9	6
M	0	13	0	0
W	2	6	0	3
D	7	3	5	2
B	4	0	1	5
S	5	5	2	8

Code

- E: Student gave unacceptable "definitions" or expressions influenced by local factors
- G: Student did a good translation into Chope, and showed good understandings in Chope. His/her understandings are scientifically acceptable, and can be understood by any Chope speaker
- M: Student used general definitions without any explanation
- W: Student gave incorrect response
- D: Student claimed no idea what the concept is
- B: Student left the response blank
- S: Student claimed he/she can only respond orally

TABLE 4.4.5.2: Summary - Circuit components and instruments (Portuguese)

Code	Students' responses in Portuguese			
	Questions			
	Q2 A voltmeter	Q5 A switch (interrupter)	Q15 A (metal) wire	Q18 A battery
R	15	3	0	0
A	0	0	0	11
E	8	21	13	10
M	0	0	13	0
W	5	3	7	5
D	0	0	0	0
B	0	0	4	2

Code

- R: Student recalled textbook definition to explain his/her understanding about the concept;
- A: Student gave acceptable definition in his/her own words;
- E: Student gave unacceptable definitions or expressions influenced by local factors;
- W: Student gave incorrect response
- D: Student claimed no idea what the concept is
- B: Student left the response blank

(voltmeter is the apparatus use to measure electric force or force of electricity). Responses suggest that students know what a voltmeter is, although some think that a voltmeter is connected in series. Another misunderstanding was that a voltmeter measures current intensity (in Portuguese), but the same students were internally consistent in Choqe. The multi-meaning of the concepts *intamo* and *guezi* in Choqe were the source of the misunderstanding (incorrect answer) when responding in Portuguese.

Students recognise circuit components and instruments through their social utility. For instance 22 students out of 28 explained a metal wire in the following way:

- In Portuguese ten students related a metal wire with electricity, while only three said it was used to tie something.
- In Choqe nine students understood a metal wire as an electric element, but 13 emphasised it as a wire often used to tie something.

According to Christie (1989) it is through language that people develop mental pictures that will always be used as a model when receiving specific stimuli. We can therefore account for the Portuguese/Choqe use of "wire" as follows: in town students often speak Portuguese, and when they talk about an (electric) metal wire they usually relate this with electricity. In rural areas Choqe speaking people relate a metal wire as something to tie or bind with, or to build a back yard. Thus in Choqe the stimulus "wire" brings the picture "tie something" or "building back yard", while in Portuguese the stimulus "wire" activates the picture "electric instrument". It is somewhat like a Pavlovian stimulus-response situation.

Students recognised a battery as a source of EMF but had difficulty to explain what EMF is as a basic electric concept. Students used an analogy: *nibattaria difeko da ntamo wa guezi* meaning that a battery is a warehouse/accumulator of electricity. During interviews the researcher found that three students who defined a battery as a warehouse had grown up in town. For students from rural areas the term "warehouse" is unusual, nor

are batteries particularly common. This hinders students' ideas about batteries in Choqe. Hence it was difficult for many students to explain in Choqe what a battery is, or to try to use an analogy to explain a battery (e.g. battery is like a well (as some students did when explaining EMF)).

Responses showed that prior experience and common usage are the main sources of students' understandings of electric components and instruments. Responses suggest too that students prefer to explain what an electric instrument or component is, rather than to give an equivalent expression or term in Choqe. This also suggests that in Choqe the equivalent words or expressions do not exist, or are unknown to students.

Some scientific words in Choqe are imported from western languages by adding a suffix or prefix. For instance: A (metal) wire is called *waiela*, a battery is called *nibateria*. For terms or expressions of more than one word (e.g. electric current intensity, source of electromotive force) a "key" word addresses the meaning of the concept. The concept metal wire (*fio metálico*) is constituted by TWO words "metal" and "wire" ("*fio*" and "*metálico*"). The student C3 chose the word *fio* as the key word and during the conceptualisation process did a literal translation from Portuguese to Choqe: he seemingly looked at the word *fio* outside of an electric context, or perhaps the word *fio* was a stimulus for his biological knowledge of fibres. Either way the student understood a metal wire as a "fibre".

A similar situation can be found in other electric concepts where teachers or students choose or understand one of the words as the key word, and through this word address the explanation. Cohen et al. (1983) advise that this didactic procedure hinders students' understanding in science classrooms: for example, it is common for students and teachers to refer to electricity as energy instead of electric energy, or electric current as current, in cases where the label "electric" may have specific importance. If the key word is incorrectly addressed or understood, then the meaning of the expression can change too. This develops in students' minds misunderstandings about fundamental electric concepts, such as electric current as

current, or potential difference as potential.

Looking at the responses in the TABLES 4.4.5.1 and 4.4.5.2 we found that:

- i) Students' understandings were strongly influenced by prior experience and common usage, both in Choape and in Portuguese.
- ii) Previous knowledge acquired through prior experience and common usage, when it is not scientifically acceptable, hinders students' learning of fundamental electric concepts (see discussions in questions 5 and 15)
- iii) Students were not able to easily acquire concepts, where these were uncommon in their ordinary environment (e.g. Q2 - the voltmeter).

CHAPTER 5

ANALYSIS OF QUESTIONNAIRE 2

5.1. INTRODUCTION

In this section we analyse the data obtained from Section 1 and Section 2 of Questionnaire 2. Twelve students out of 28 were chosen as the sample for this part of the study.

In Section 1 we discuss translations made by students of scientific sentences related with electricity from Portuguese to Choze. We assume that if students translate word-by-word from Portuguese into Choze, then they do not understand the real meaning of the sentence either in Portuguese or Choze, and do not understand the scientific content which the sentence conveys.

In Section 2 we assess the relationship between students' understanding and how they translate the sentence (how they understand the sentence in their mother tongue).

The analysis of these sentences was done by looking at students' responses as summarised in TABLES 5.2.1/2 (page 82), 5.2.3 (page 83), 5.3.1 (page 84) and 5.3.2 (page 85). The tables indicate the types of translation for each task.

5.2. SECTION 1 QUESTIONNAIRE 2

5.2.1. Sentence 1 (TABLE 5.2.1)

(Voltage is shared equally between identical elements in a series circuit).

Four students gave scientifically and internally acceptable translations. The translations included also scientific terms:

- C1: Ch: Intamo wa guezi uo ahawanitswa ngu ku pfana ku sotse si gotso so landana sikhu indane ka tsila ya guezi.
E: Voltage is shared equally through/by all the electric elements in series in an electric circuit

Seven students translated the sentence without translating ALL scientific terms. Some translations were:

- C2: Ch: Voltagem yi abanitswa in kupfana ka sotse sigotso sa circuito elétrico so landana ("literal" translation from Portuguese to Choze underlined)

E: Voltage is shared equally among/between electric elements in series circuits.

One students mixed Portuguese and Choze during his "translation", in both scientific terms as well as in ordinary words.

5.2.2. Sentence 2 (TABLE 5.2.2)

(A resistor R is connected in series to a source which has no internal resistance. A second identical resistor is then connected to the first in parallel).

Six students did not translate ALL scientific terms although they translated the content:

C12: Ch: *Tchomba pindissa guezi tohi lungahitinwe yinku laudana ni tchissima tcha guezi tchakuva tchisikane tchinonoyisso tsa tsila ya guezi. Tchomba pindissa guezi tcho pfana ni tcho khata tohi lungahitinwe em paralele ni tcho kata*

E: Electric resistance is connected in series with an electric source without resistance. Another resistance identical to the first one is connected in parallel with this.

Students used two different terms to define resistance: *tchomba phindissa* (...which blocks) and *tchinonoyisso* (...hinders passage or makes passage difficult). During the interview students explained that they used the two different terms as follows:

- Internal resistance makes the passage of electrons difficult through the voltage source.
- External resistance blocks the passage of electrons through the electric circuit.

For students the function of resistance in an electric circuit is to prevent the current passing (resistance devours/uses current), although the function of a bulb is to light. Students do not understand what a resistance is.

Two students mixed languages, however translated the meaning of the sentences. Three students asserted they were only able to translate the sentence orally, because the sentence in Portuguese included (too) many scientific terms. They claimed too that a correct translation might demand more space than was provided on the paper.

5.2.3. Sentence 3 (TABLE 5.2.3)

(The potential difference between the ends of a light bulb in which current flows is determined by the difference in energy between the charges moving at its two ends).

Five students translated the sentence in the following way:

- C18: Ch: Ku hambana ka intamo wa guezi maguito ni maguito ka dilambo di tsimbiliuaku ngu guezi ku kombwa ngu ku hambana ka intamo wa guezi wa macarga maguito di maguito ka dilambo.
E: Potential difference between the extremes (ends) of a bulb is determined by the electric charge that it is flowing through the extremes of the bulb.

Seven students left some scientific terms untranslated:

- C23: Ch: Ku hambana ka intamo wa guezi nos extremos duma lampada nitsimbiliuako ku insinga wa guezi ku kombitwa ngu ku hambana ka intamo wa guezi uku ka macarga electric ma tsekatekaku maguito ni maguito.
E: Potential difference in extremes of a bulb is determined by current of electric charge that it is flowing through a bulb

Seven students' responses showed that the expression "que se move" (which moves) was understood as "which is not static". This expression does not express the idea of flowing or motion in one direction.

During interviews the researcher asked what the meaning of the phrase "matsekatekaku maguito ni maguito" means in the context of the sentence:

"Ku hambana ka intamo wa guezi nos extremos duma lampada nitsimbiliuako ku insinga wa guezi ku kombitwa ngu ku hambana ka intamo wa guezi uku ka ma cargas electric matsekatekaku maguito ni maguito"

Students (e.g. C1) said:

"I think that the better expression is not kutsekateka but should be ngugulhuvetana. Ngugulhuvetana means chaotic motion of anything, however flowing in one direction. Kutsekateka means a chaotic motion of anything without flowing in one direction".

This point of view was supported by two other students in the following way:

"It is very difficult to agree that electrons or electric charge can have 100% of unidirectional motion because we have learned that any body is made up of small particles which have Brownian motion. Even if it is not the case, if we look at children as they go from school they play, often running in different

directions. The same situation we found when we take the cows to the river: they are moving in many directions or they stop on the way".

What external effect can completely change this natural fact? was the interesting question which students raised.

When I asked them why they never discussed this question in the classroom they said:

"it is difficult to get time in the classroom, and how can we discuss something that comes from teachers and textbooks? Also, is not good to show your teacher that you have big or bad understanding in his subject otherwise....?"

It was interesting to find this point of view among students. These ideas are supported by previous knowledge that students acquired in their childhood environment (local factors). Previous knowledge in this case could be a good foundation to develop teaching in science classes.

Three students asserted that they did not understand the meaning of the sentences, so it was difficult for them to translate.

5.3. SECTION 2 OF QUESTIONNAIRE 2

5.3.1. Statement 1 (TABLE 5.3.1)

(Mention two uses of metal wire)

Most students were able to translate the statement and answer the question in part (ii). Two translations were:

C12: Ch: *Kombisa mithumo yimbidi ya lingoti la simbi*
C18: Ch: *Tchatchameta mithumo yimbidi ya waiela*

However three students changed words during translation:

C10: Ch: *Kombisa mithumo yimbidi ya lingoti la guezi (students wrote lingoti la guezi instead of lingoti la simbi).*

As for the case of metal wires students too were able to give good examples:

C8: Ch: *Waiela yi thumela timaka thatinji, kupfana ni kuria sipmangua, kumbe ku lunghalheta guezi hambi ku sunga inkitary.*
E: *A metal wire has many uses, for instance, to make a trap or to connect an electric element into an electric circuit or to tie back a yard.*

5.3.2. Statement 2 (TABLE 5.3.2)

(Does electric current flow across an electric circuit or through an electric circuit? Explain your answer).

Students found difficulty translating the sentence. Only two were able to translate the sentence partially (code "S"):

C2: Ch: *Insiga wa guezi uo tsimbila atravéz (across) ya circuit electric kumbe ku indane (through) ka sigotso sa guezi*

Most students found difficulty understanding the words across and through.

The impact of students' weak understanding of this sentence was evident in the task (ii). Only two students could give a correct answer, and they did not give any explanation to clarify/justify the response. Six students asserted they were not able to translate the sentence: they claimed that the sentence is not clear.

5.3.3. General comments on Statements 1 and 2

The sentence 1i, the task of answering the question 1ii was reasonably handled by most students.

In this task students showed some influence of local factors in their understanding. For instance C8 quoted a possible use of metal wire was to make a trap (perhaps when young, he had done this). Students from urban areas often related a metal wire with electricity (not necessarily with electric current). No one related metal wire with a phone circuit: phones are not common in many Mozambican families even in Maputo.

By comparison, students found sentence 2i difficult: the reason was not so much scientific terms but the two words ACROSS and THROUGH that hindered students' understanding. These two words also interfered negatively in students' responses in 2ii.

5.4. GENERAL CONCLUSIONS ON CHAPTER 5

Responses showed that on average students did reasonable translations. They did not translate words but content, and were not able to translate ALL scientific terms. This is not strange because Chope is not a scientifically oriented language, not is

it the instructional language.

Responses showed that when expressions comprised more than one word (e.g. potential difference, electric energy) this develops special difficulties for students' translations:

- Students prefer to translate the content. If they found an expression not translatable they prefer to use the Portuguese expression. Students' translations generally make sense, and can be used as an auxiliary element to explain to Chope speakers the intended meaning of a statement.
- Translations made by fluent Chope speakers (e.g. C12) can be understood by any Chope speaker.
- Some students do not know all scientific terms in Chope.
- Some words (e.g. parallel) do not have an equivalent word in Chope, although other words (e.g. series) do.
- Not only scientific words are difficult for students, but also common words (e.g. words like through and across). These words hinder students' understanding, and consequently communication, in science classes.
- Local factors as previous knowledge can be
 - useful for students' acquiring new knowledge, or to develop good teaching and learning in science classes (e.g. students' ideas about the motion/definition of electric current), or
 - they can hinder the learning process when the common definition is unscientific (e.g. "social" definition of "work").

TABLE 5.2.1 (Questionnaire 2, Section 1, Sentence 1)**(Voltage is shared equally between identical elements in a series circuit)**

Personal details	Kind of translation from Portuguese to Chope												
Age	32	20	24	23	26	32	26	28	16	32	21	21	
Gender	M	F	F	M	M	F	M	M	M	M	F	M	
Stud. C _N	1	2	3	4	10	12	13	15	16	17	18	21	TOTAL
T	*							*		*	*		4
S		*	*		*	*	*		*			*	7
M				*									1

CODE

- T: Students gave a good translation when translating both scientific terms and ordinary words;
 S: Students did not translate ALL scientific terms;
 M: Students mixed languages (Portuguese and Chope) during their translations.

TABLE 5.2.2 (Questionnaire 2, Section 1, Sentence 2)**(A resistor R is connected in series to a source which has no internal resistance. A second identical resistor is then connected to the first in Parallel).**

Personal details	Kind of translation from Portuguese to Chope												
Age	32	20	24	23	26	32	26	28	16	32	21	21	
Gender	M	F	F	M	M	F	M	M	M	M	F	M	
Stud. C _N	1	2	3	4	10	12	13	15	16	17	18	21	TOTAL
S			*		*			*	*	*		*	6
W						*							1
M	*			*									2
V		*					*				*		3

CODE

- S: Students did not translate ALL scientific terms;
 W: Students translated the sentence word by word;
 M: Students mixed languages (Portuguese and Chope) during their translations;
 V: Students are only able to translate orally.

TABLE 5.2.3 (Questionnaire 2, Section 1, Sentence 3)

(The potential difference between the ends of a light bulb in which current flows is determined by the difference in energy between the charges moving at its two ends).

Personal details	Kind of translation from Portuguese to Chope												
Age	32	20	24	23	26	32	26	28	16	32	21	21	
Gender	M	F	F	M	M	F	M	M	M	M	F	M	
Stud. C _N	1	2	3	4	10	12	13	15	16	17	18	21	TOTAL
S	*		*			*		*		*			5
V		*	*	*			*		*		*	*	7

CODE

- T: Students gave a good translation when translating both scientific terms and ordinary words;
 S: Students did not translate ALL scientific terms.

TABLE 5.3.1 (Questionnaire 2, Section 2, Statement 1)

(Mention two uses of metal wire).

Personal details	Kind of translation from Portuguese to Chope (li)												
Age	32	20	24	23	26	32	26	28	16	32	21	21	
Gender	M	F	F	M	M	F	M	M	M	M	F	M	
Stud. C _N	1	2	3	4	10	12	13	15	16	17	18	21	TOTAL
T	*			*		*			*	*			5
S		*	*		*		*	*				*	6
D											*		1
	Responses (lii)												
P		*	*		*	*		*		*	*		7
U	*						*					*	3
B				*					*				2

CODE

Section li:

- T: Students gave a good translation when translating both scientific and ordinary words;
- S: Students did not translate ALL scientific terms;
- D: Students not able to translate the sentences.

Questions lii:

- P: Correct answer;
- U: Students gave inadequate response (e.g. gave only one application of a metal wire, or changed words in translation);
- B: Left the response blank.

TABLE 5.3.2 (Questionnaire 2, Section 2, Statement 2)

(Does electric current flow across an electric circuit or through a electric circuit? Explain your answer).

Personal details	Kind of translation from Portuguese to Choape (2i)												
Age	32	20	24	23	26	32	26	28	16	32	21	21	
Gender	M	F	F	M	M	F	M	M	M	M	F	M	
Stud. CN	1	2	3	4	10	12	13	15	16	17	18	21	TOTAL
S		*							*				1
M				*								*	2
W					*	*							2
D	*		*				*	*		*	*		6
	Responses (2ii)												
B	*		*					*			*		4
F				*		*				*			3
N					*		*					*	3
P		*							*				2

CODE

Section 2i:

- S: Students did not translate ALL scientific terms;
- M: Students mixed languages (Portuguese and Choape) during their translations;
- W: Students translate word by word within the sentence;
- D: Students not able to translate the sentences.

Questions 2ii:

- B: Response left blank;
- F: Correct answer without any explanation;
- N: Incorrect answer;
- P: Correct answer.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The AIM of this study was to research the influence of Chope as mother tongue on the learning and understanding of fundamental electric concepts among BUSCEP Chope students.

Students used a writing task as the main research instrument for data collection, and an interview as an auxiliary instrument.

The study sample was the 1997 subclass of BUSCEP Chope speakers. The FOCUS of the study was:

- Does the Chope language have any influence on Physics BUSCEP students who are native Chope speakers in understanding the precise meaning of:
 1. Ordinary words often used in the instructional language (Portuguese)?
 2. Physics terms used during teaching and learning the section on electricity in the BUSCEP course?

The study showed that students were often able to speak and develop different or similar pictures/models in Chope or Portuguese without language interference. The study revealed too that students often use knowledge acquired through Chope when speaking Portuguese, and that it is unusual to do a literal word-by-word translation or transfer from Chope to Portuguese. In general, Chope did not interfere with BUSCEP Physics students' understanding of the meaning of ordinary words used in Portuguese.

Many students were however weak in Portuguese. This interferes with their understanding of some words or phrases, and consequently hinders comprehension and general communication. This weakness was reflected when students were asked to translate some sentences from Portuguese to Chope. For instance in Section 4 many students were unable to translate the statement because it included ordinary words (across and through). This weakness is more evident when students do not find any equivalent word in

Chope as prior knowledge to help understand the meaning of the word.

In this study we found that Chope strongly influences students' understanding of the precise meaning of physics terms, particular fundamental electric concepts.

This study revealed that Chope words relating to electricity often have more than one meaning, where the precise meaning of the word or expression can only be known within the context.

The multi-meaning of Chope words often causes students to understand a concept incorrectly. For instance in Chope the expression *intamo* (force) defines ALL interactions and their development. If the word *intamo* is joined with the word *guezi*, we found that the expression *intamo wa guezi* (electric force OR force of electricity) defines ALL electric phenomena (electric interactions) and their development. Thus in science classes native Chope speakers use the concept "electric force" to define also concepts such as electric power, electric intensity and electric energy.

Another source of misunderstanding of fundamental electric concepts is that the "common sense" terminology and usage of certain electric elements (e.g. interrupter) within the community does not concord well with strict scientific norms. Students get confused when they are faced with two different and conflicting viewpoints.

In this study we found that prior knowledge that is not scientifically acceptable hinders students understanding about the concept in question. This applies regardless of whether the prior knowledge was acquired through Chope or Portuguese.

Responses revealed that students sometimes show different behaviours when discussing fundamental electric concepts. Many electric concepts which were discussed among students (such as pre-requisite concepts and basic concepts) related to the strictly scientific domain, and so many students used Portuguese. But for common concepts in their everyday life, such as electric components or instruments, students prefer to mix languages. Among Chope speakers this has become a habit.

From the results of the survey we conclude that:

1. BUSCEP students who are native Chope speakers often use knowledge acquired through Chope as prior knowledge to understand, or better understand, some precise meanings in Portuguese.
2. Students use Chope and Portuguese independently; i.e. Chope is an independent stimulus to develop or activate specific pictures in students' minds. The same conclusion is also valid in Portuguese.
3. Students' weakness in the instructional language (Portuguese) hinders communication in the classroom. Weaknesses are more evident in language structure and vocabulary.
4. Students prefer to explain the meaning of a concept rather than to use equivalent words or expressions.
5. Local factors such as language, cultural habits and childhood environment are the source of much prior knowledge that interferes strongly in students' (mis)understandings of fundamental electric concepts.
6. There are students who use prior knowledge to adjust the new knowledge being acquired in science classes.
7. BUSCEP students showed common misunderstandings about funda/mental electric concepts (as indicated in the literature review). The research also suggested that some didactic procedures reinforce students' weakness in understanding some concepts (e.g. interrupter, electric current intensity, electric current).
8. There are students that have particular difficulties in understanding concepts with more than one word (e.g. electric power, electric field), especially when one of these words is common within the students' vocabulary, but which has a meaning which is unacceptable scientifically.
9. The study also reflects that there are students that develop specific pictures in their mind according to the language they are speaking (e.g. when speaking Portuguese they relate metal wire with electricity, but when speaking Chope they relate metal wire with material to tie or make

a back yard).

10. The research showed that students' vocabulary in Chope is often very limited, although a few students wrote and spoke well in Chope, with a more extensive range of words. On the other hand some students "manipulate" Chope to good effect.

The study was not intended to generalise the present findings, but rather to get some idea of possible factors that hinder the learning process among Chope students. Our belief is that this research should be useful for educational experts, teachers and Chope speaking Mozambican communities.

It was helpful for the researcher to recognise that every student had also been influenced by other external factors which construct in his/her mind concepts, models, pictures ... even before attending any formal education. Students consciously or subconsciously use this prior knowledge as an anchor while learning new concepts (including fundamental electric concepts). The interviews showed that students may not be aware of these facts. They were able to think about the same concept in Chope and in Portuguese in two different ways. Often students stated different arguments or gave different examples to support their explanations (although their views sometimes remained the same).

Educational researchers and teachers need to be aware of the existence of previous knowledge in students' minds that could be useful, or otherwise, for the teaching and learning process. Teachers need to develop good strategies to both utilise and counter students' previous knowledge in order to arrive at new knowledge and acceptable scientific models. The interviews revealed that some students prefer to "hide" their previous knowledge because they are not sure whether this will be acceptable to their teachers or not.

The findings of this study suggest that Chope is not yet able to be/become an instructional language. However it could be a useful aid during teaching and learning in science classes.

The study also showed that educational experts and teachers need to research how Mozambican mother tongues could be used in

Mozambican schools.

This research was, as far as could be ascertained, the first done in Mozambique on the influence of the mother tongue in learning fundamental electric concepts. The researcher recognises that the design of this study did not permit him to assess as deeply as possible how Chope (or any mother tongue) or other local factors interfere in the teaching and learning of science. The researcher hopes that other more extensive and detailed work may throw more light on the issue in the coming years.

Additional Note:

- An interesting fact was observed during this research. The number of students that fail to understand a concept in Chope and in Portuguese is more less the same: this fact became more interesting because only the number of students were the same but the students were almost always different.
- For concepts that students often use in their ordinary life, and which they relate with activities (e.g. electricity, energy), responses were influenced by gender - e.g. females related energy with heat while males related energy with force.

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APPENDIX 1

THE RESEARCH INSTRUMENT (QUESTIONNAIRE)

(a) ENGLISH VERSION (PINK PAGES)

QUESTIONNAIRE 1

In this section you are given twenty (20) terms related to electricity.

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms.

Under your explanation there is a block:

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

Place a cross over one of these classifications to show how well you understand the term.

Thank you for your co-operation!

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

1. Energy

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

2. Voltmeter

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

3. Electrical resistance

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

4. (Electric) current intensity

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

5. A switch ("interrupter")

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

6. An insulator

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

7. Electric field

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

8. Electric power

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

9. Conventional current

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

10. An electric circuit

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

11. Load

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

12. Electric current

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

13. Electric charge

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

14. A parallel circuit

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

15. (Metal) wire

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

16. Potential difference

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

17. A source of electromotive force

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

18. A battery

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

In each case explain in Portuguese (P) and in your own mother tongue (MT) what you understand by the meaning of these terms. Under your explanation there is a block. Place a cross over one of these classifications to show how well you understand the term.

19. Electricity

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

20. Work

P: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

MT: _____

very well	well	only slightly	do not understand	just guessing
-----------	------	---------------	-------------------	---------------

Surname: _____ Initials: _____

QUESTIONNAIRE 2

SECTION 1

a) Translate the following three sentences into your own mother tongue

1. Voltage is shared equally between identical elements in a series circuit.

A: _____

2. A resistor R is connected in series to a source which has no internal resistance. A second identical resistor is then connected to the first in parallel.

A: _____

3. The potential difference between the ends of a light bulb in which current flows is determined by the difference in energy between the charges moving at its two ends.

A: _____

SECTION 2

(i) Translate the following statement into your mother tongue and then,

(ii) Answer the statement in your mother tongue

1. Mention two uses of metal wire.

(i) [translation]

(ii) [Answer]

2. Does electric current flow across an electric circuit or through an electric circuit? Explain your answer.

(i) [Translation]

(ii) [Answer]

APPENDIX 1

**THE RESEARCH INSTRUMENT
(QUESTIONNAIRE)**

**(b)
PORTUGUESE VERSION
(YELLOW PAGES)**

Universidade Eduardo Mondlane
Faculdade de Ciências
Departamento das Ciências Básicas

INFORMAÇÕES GERAIS

Caro estudante

Todas as informações que serão obtidas através deste questionário serão usadas apenas para a investigação.

1.0 Apelido: _____

1.1 Nome: _____

1.2 Data de nascimento: _____

1.3 Sexo: M F

1.4 Que língua é que fala na sua casa (língua materna)?

1.5 Será o Português a sua primeira segunda or terceira língua?

1.6 Qual é(são) as língua(s) que você fala com os seus amigos?

1.7 Qual é a língua que você fala com os seus familiares?

POR FAVOR NAO DISCUTA ESTE TRABALHO (QUESTIONÁRIO) COM OS SEUS COLEGAS DURANTE SUA RESOLUÇÃO, ISTO É, NA SALA DE AULAS.

MUITO OBRIGADO PELA SUA COOPERAÇÃO !

QUESTIONÁRIO 1

Nesta secção é lhe dado(a) vinte (20) termos relacionados com a electricidade. Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos.

No fim da sua explicação há um "bloco" como este:

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

Por favor ponha uma cruz sobre a classificação que indica como você entende o termo

OBRIGADO PELA SUA COOPERAÇÃO!

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

1. Energia

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

2. Voltímetro

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

3. Resistência eléctrica

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

4. Intensidade da corrente (eléctrica)

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

5. Um interruptor

P: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

LM: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

6. Um isolador

P: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

LM: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

7. Campo eléctrico

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

8. Potência eléctrica

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

9. Corrente convencional

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

10. Um circuito eléctrico

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

11. Carga

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

12. Corrente eléctrica

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

13. Carga eléctrica

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

14. Um circuito eléctrico em paralelo

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

15. Fio (metálico)

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

16. Diferença de potencial

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	----------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor ponha uma cruz sobre a classificação que indica como você entende o termo.

17. Uma fonte da força electromotriz (fem)

P: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

LM: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

18. Uma bateria

P: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

LM: _____

 muito bem 	 bem 	 só um pouco 	 não entendo 	 apenas advinho
--------------------	--------------	----------------------	----------------------	-------------------------

Em cada caso explique em Português (P) e na sua língua materna (LM) o que é que você entende por cada um destes termos. No fim da sua explicação há um "bloco". Por favor, ponha uma cruz sobre a classificação que indica como você entende o termo.

19. Electricidade

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

20. Trabalho

P: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

LM: _____

muito bem	bem	só um pouco	não entendo	apenas advinho
-----------	-----	-------------	-------------	-------------------

Apelido _____ Iniciais: _____

QUESTIONÁRIO 2

SECÇÃO 1

a) Traduza as seguintes três expressões para a sua língua materna (LM).

1. A voltagem é compartilhada de forma equitativa por todos os elementos idênticos num circuito eléctrico em série.

R: _____

2. Uma resistência R é ligada em série a uma fonte que não tem (sem) resistência interna. Uma segunda resistência idêntica é primeira é ligada á primeira em paralelo

R: _____

3. A diferença de potencial entre os extremos duma lâmpada que é percorrida pela corrente é determinada pela diferença de energia das cargas que se movem entre os dois extremos (da lâmpada).

R: _____

SECÇÃO 2

- (i) Traduza a seguinte afirmação para a sua língua materna e depois,
- (ii) Escreva a resposta na sua língua materna.

1. Mencione duas aplicações de um fio metálico

(i) [Tradução] _____

(ii) [Resposta] _____

2. A corrente eléctrica flui sobre o circuito eléctrico ou através de circuito eléctrico?
Dê uma explicação da sua resposta

(i) [Tradução] _____

(ii) [Resposta] _____

APPENDIX 2

ANALYSIS OF QUESTIONNAIRE 1

Section 4.2

Pre-requisite electric concepts

Section 4.3

Basic concepts of DC circuits

Section 4.4

Circuit components and instruments

TABLE 4.2.1: ANALYSIS OF QUESTION 1 (Energy)

ENERGY			Portuguese					Chope				Comments	
Personal information			Ideas					Ideas					
Student	Gender	Age	E	F	C	H	O	I	G	S	O		
C1	M	32		*	*							*	F-C
C2	F	20		*	*							*	F-C
C3	F	24			*	*						*	C-H
C4	M	23					*					-	
C5	M	37					*	*					
C6	M	--				*					*		
C7	M	19			*			*	*				C-G and I-G
C8	M	21	*									-	particular case
C9	M	21	*									-	
C10	M	26	*					*					
C11	M	25					-/					-/	OUT
C12	F	32			*				*				C-G
C13	M	26		*				*					F-I
C14	M	16		*				*					F-I
C15	M	28	*										
C16	M	16				*		*					
C17	M	32	*			*						-	
C18	F	21		*				*					F-I
C19	M	27			*							-	
C20	F	--			*	*						-	C-H
C21	M	21		*				*	*				F-I and I-G
C22	M	21	*								*		
C23	M	21					*				*		
C24	M	21	*					*					
C25	M	22	*									-	
C26	F	--			*	*		*					C-H
C27	M	34	*						*				
C28	M	28		*				*					F-I
TOTAL			9	7	8	6	3	11	4	3	10		N=27

Code
Portuguese

- E: Enables an object to do work
 F: Force (produced or necessary) to do work
 C: Electric current
 H: Heat and/or transfer of heat
 O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- I: *Intamo* (Force)
 G: *Guezi* (Electricity, Electric current)
 D: Students claimed they do not have any idea about the concept
 S: Students claimed they know the meaning of the concept, but are only able to respond orally
 O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.2.2: ANALYSIS OF QUESTION 7 (Electric field)

Electric field			Portuguese			Chope				Comments	
Personal Information			Ideas			Ideas					
Student	Gender	Age	E	D	O	U	D	S	O		
C1	M	32			-	*					"-U
C2	F	20	*			*					E-U
C3	F	24	*			*					E-U
C4	M	23	*			*					E-U
C5	M	37	*				*				E-D
C6	M	-	*					*			E-S
C7	M	19	*			*					E-U
C8	M	21			*				-		O-"
C9	M	21			*				-		O-"
C10	M	26			*	*					O-U
C11	M	25			-/				-/	OUT	
C12	F	32		*			*				D-D
C13	M	26	*			*					O-U
C14	M	16			*	*					E-U
C15	M	28	*						*		E-O
C16	M	16	*			*					E-U
C17	M	32			*	*					O-U
C18	F	21	*			*					E-U
C19	M	27			*				-		O-"
C20	F	-			-/				-/	OUT	
C21	M	21			*				*		O-O
C22	M	21	*				*				E-D
C23	M	21	*					*			E-S
C24	M	21			*				-		O-"
C25	M	22	*						-		E-"
C26	F	-			*				-		O-"
C27	M	34	*						-		E-"
C28	M	28	*						-		E-"
TOTAL			15	1	10	11	3	2	10		N = 26

Code

Portuguese

- E: Electric field is an area around an electric charge where the effect of the charge is felt
- D: Students claimed they have no idea about the concept
- O: Other responses (responses that are not stating common ideas are indicated as "*", blank as "-" and blank in both languages as "-/')

Chope

- U: *Ukalo kumbe yi thembwe ku pfalaku Intamo wa guezi* (Area, place or region where an electric force is felt)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/')

TABLE 4.2.3: ANALYSIS OF QUESTION 11 (Load)

Load			Portuguese			Chope						
personal information			Ideas			Ideas						
Student	Gender	Age	E	Q	O	I	G	D	S	O	Comments	
C ₁	M	32	*	*	*	*	*			*	Special 1	I-G
C ₂	F	20	*			*	*				E-I	
C ₃	F	24	*							-	E-"	
C ₄	M	23			*					-		O-"
C ₅	M	37	*					*			E-D	
C ₆	M	-			-	*						"-I
C ₇	M	19		*					*			Q-S
C ₈	M	21	*			*					E-I	
C ₉	M	21			-			*				"-D
C ₁₀	M	26	*			*					E-I	
C ₁₁	M	25			-				*			"-S
C ₁₂	F	32	*			*					E-I	
C ₁₃	M	26	*	*	*	*					Special 1	I-G
C ₁₄	M	16	*	*	*	*	*				Special 1	I-G
C ₁₅	M	28	*			*	*				E-I	
C ₁₆	M	16	*	*	*				*		Special 2	
C ₁₇	M	32	*	*	*	*	*				Special 1	I-G
C ₁₈	F	21	*	*					*		Special 2	I-G
C ₁₉	M	27		*					*			Q-D
C ₂₀	F	-			-/					-/	OUT	
C ₂₁	M	21		*	*	*	*				Special 3	I-G
C ₂₂	M	21			*				*			
C ₂₃	M	21			*				*			O-S
C ₂₄	M	21			*					-		O-"
C ₂₅	M	22		*						-		Q-"
C ₂₆	F	-			-/					-/	OUT	
C ₂₇	M	34			-/					-/	OUT	
C ₂₈	M	28	*		*	*						Q-I
TOTAL			14	10	14	12	6	3	6	5	N = 25	

Code

Portuguese

- E: Load is anything that it is carried/ delivered
- D: Load is quantity of electrons transported by electric current
- O: Other responses (responses that re not stating common ideas are indicated as "*", a blank as "-" and & blank in both languages as "-/')

Chope

- I: *load intualo/inthualo kumbe ichidjumba* (anything that it is carried/transported)
- G: *Intamo wa guezi* (electric force or force of electricity)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that re not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/')

TABLE 4.2.4: ANALYSIS OF QUESTION 13 (Electric charge)

Electric charge			Portuguese				Chope					
Personal information			Ideas				Ideas					
Student	Gender	Age	C	P	A	O	I	D	S	O	Comments	
C1	M	32	*				*				C-D	
C2	F	20	*				*				C-D	
C3	F	24				-	*					"-"-D
C4	M	23	*				*				C-D	
C5	M	37	*				*				C-D	
C6	M	--				-	*					"-"-D
C7	M	19		*					-			A-"-
C8	M	21				-/			-/	OUT		
C9	M	21	*	*					-	C-"-		
C10	M	26				-	*					"-"-D
C11	M	25		*					*		P-S	
C12	F	32		*			*					A-I
C13	M	26		*			*				P-D	
C14	M	16				-/			-/	OUT		
C15	M	28		*					*		P-O	
C16	M	16	*				*			C-I		
C17	M	32		*			*					A-I
C18	F	21		*					*			A-O
C19	M	27		*			*					A-O
C20	F	--				-/			-/	OUT		
C21	M	21	*				*				C-I	
C22	M	21		*					*		P-S	
C23	M	21	*						*		C-S	
C24	M	21		*			*					A-O
C25	M	22				-	*					"-"-D
C26	F	--	*						-	C-"-		
C27	M	34				-/			-/	OUT		
C28	M	28				-/			-/	OUT		
TOTAL			9	4	6	4	2	13	3	5	N = 23	

Code

Portuguese

- C: Electric charge is electric capacity
- P: Electric charge is an electric particle
- A: Incorrect explanation, but internally consistent
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- I: *Electric charge Intamo wa guezi* (Electric force or force of electricity)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common idea are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.2.5: ANALYSIS OF QUESTION 19 (Electricity)

Electricity			Portuguese			Chope						
Personal information			Ideas			Ideas						
Student	Gender	Age	M	C	Q	O	N	D	S	O	Comments	
C1	M	32	*				*N				M-*N	
C2	F	20			*		*N					Q-*N
C3	F	24			*		*					Q-N
C4	M	23		*			*				C-N	
C5	M	37				-	*					"-"-N
C6	M	--				-	*					"-"-N
C7	M	19		*			*				C-N	
C8	M	21		*				*			C-D	
C9	M	21	*						-		M-"."	
C10	M	26	*					*			M-S	
C11	M	25				-	*					"-"-N
C12	F	32			*		*N					Q-*N
C13	M	26				-	*N					"-"*N
C14	M	16			*		*N					Q-*N
C15	M	28		*			*					C-N
C16	M	16			*		*					Q-N
C17	M	32	*				*				M-N	
C18	F	21	*				*N				M-*N	
C19	M	27				*	*					O-N
C20	F	--				-			-		OUT	
C21	M	21				-	*					"-"-N
C22	M	21		*				*			C-S	
C23	M	21				-			-		OUT	
C24	M	21		*					-		C-"."	
C25	M	22		*				*			C-D	
C26	F	--			*				-			Q-"."
C27	M	34				-			-		OUT	
C28	M	28				-			-		OUT	
TOTAL			5	7	6	6	17	2	2	3	N = 24	

Code

Portuguese

- M: Electricity is electric current motion OR motion of electric charge
 C: Electricity is Chapter of Physics
 Q: Electricity is calorific energy
 O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- N: *Electricity yi guezi kumbe indilo wa guezi* (is electricity OR electric current OR fire of electricity/electric current is electricity)
 *N: Students that relate directly electricity with heat
 D: Students claimed they have no idea about the concept
 S: Students claimed they know the meaning of the concept, but are only able to respond orally
 O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.2.6: ANALYSIS OF QUESTION 20 (Work)

Work			Portuguese				Chope				Comments	
Personal information			Ideas				Ideas					
Student	Gender	Age	W	P	E	O	K	I	N	S	O	
C1	M	32			*				*			E-N
C2	F	20		*					*			P-S
C3	F	24			*				*			E-N
C4	M	23		*				*				P-I
C5	M	37			*				*			E-N
C6	M	-				*					-	O-"."
C7	M	19				*					*	O-O
C8	M	21		*							-	P-"."
C9	M	21				-/					-/	OUT
C10	M	26			*			*				E-I
C11	M	25	*						*			W-S
C12	F	32			*				*			E-N
C13	M	26			*			*				E-I
C14	M	16			*			*				E-K
C15	M	28		*				*				P-I
C16	M	16			*			*				E-I
C17	M	32				*		*				O-I
C18	F	21		*				*				P-I
C19	M	27	*								-	W-"."
C20	F	-		*							-	P-"."
C21	M	21				-/					-/	OUT
C22	M	21	*						*			W-S
C23	M	21				-/					-/	OUT
C24	M	21	*						*			W-S
C25	M	22		*				*				P-I
C26	F	-			*			*				E-I
C27	M	34	*						*			W-N
C28	M	28				*					-	O-"."
TOTAL			5	7	9	4	2	8	5	4	6	N = 25

Code

Portuguese

- W: Work is force times displacement
- P: Work is the displacement created/produced by a force
- E: Work is result of a force done by an animal, person or engine
- O: Other responses (responses that are not stating common ideas are indicated a "*", a blank as "-" and blank in both languages as "-/")

Chope

- K: *Inthumo kutikarata/kutchukuma ngu tchomaha* (effort to achieve anything)
- I: *Inthumo* (Work)
- N: *Njikombitso tcha inthumo wanthu* (work is fruit/result that someone can do and state)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common idea are indicated a "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.1: ANALYSIS OF QUESTION 3 (Electric resistance)

Electric Resist.		Portuguese			Chope						
personal information		Ideas			Ideas						
Student	Gender	Age	M	O	T	B	D	S	O	Comments	
C1	M	32	*			*				M-B	
C2	F	20	*						-	M-"."	
C3	F	24	*			*				M-B	
C4	M	23	*						*	M-O	
C5	M	37		-			*			"."-D	
C6	M	--		-/					-/	OUT	
C7	M	19	*						-	M-"."	
C8	M	21	*						-	M-"."	
C9	M	21		*					-		O-"."
C10	M	26	*		*	*				M-T and T-B	
C11	M	21	*						-	M-"."	
C12	F	21	*		*					M-T	
C13	M	26		-/					-/	OUT	
C14	M	16		*					*		O-O
C15	M	28	*			*				M-B	
C16	M	16		*					*		O-O
C17	M	32		*	*						O-T
C18	F	21		*					*		O-O
C19	M	27		*					-		O-"."
C20	F	--		*					-		O-"."
C21	M	21	*		*					M-T	
C22	M	21		*				*			O-S
C23	M	21	*					*		M-S	
C24	M	21	*		*					M-T	
C25	M	22		-/					-/	OUT	
C26	F	--		-/					-/	OUT	
C27	M	34	*					*		M-S	
C28	M	28	*			*				M-B	
TOTAL			15	9	5	6	1	3	1		N = 24
									1		

Code

Portuguese

- M:** Electric resistance is a friction which opposes the motion of electric current
- O:** Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- T:** *Intamo wa ku kuli tchukumisa tchipfalela guezi* (force/effort of opposition of electric current in a wire)
- B:** *Njimaha tchitsimbako ku guezi yi hinda yotse ka waiela* (something that prevents electric current passing through an electric wire)
- D:** Students claimed they have no idea about the concept
- S:** Students claimed they know the meaning of the concept, but are only able to respond orally
- O:** Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.2: ANALYSIS OF QUESTION 4 (Electric current intensity)

Electric Current Intensity			Portuguese			Chope					Comments	
Personal information			Ideas			Ideas						
Student	Gender	Age	Q	D	O	I	M	D	S	O		
C1	M	32			*	*						O-I
C2	F	20			*					*		O-O
C3	F	24	*				*					Q-M
C4	M	23			*	*						O-I
C5	M	37	*							-		Q-"."
C6	M	--			-/					-/		OUT
C7	M	19	*			*						Q-I
C8	M	21	*							-		Q-"."
C9	M	21			*					-		O-"."
C10	M	26	*			*						Q-I
C11	M	25	*							-		Q-"."
C12	F	32		*				*				D-D
C13	M	26	*			*						Q-I
C14	M	16			*					*		O-D
C15	M	28	*			*						Q-I
C16	M	16	*				*					Q-M
C17	M	32	*				*					Q-M
C18	F	21	*			*						Q-I
C19	M	27			*					-		O-"."
C20	F	--			*		*					O-M
C21	M	21			*					*		O-O
C22	M	21			-/					-/		OUT
C23	M	21			*				*			O-S
C24	M	21			*					-		O-"."
C25	M	22	*							-		Q-"."
C26	F	--			*					-		O-"."
C27	M	34	*					*				Q-D
C28	M	28	*							-		M-"."
TOTAL			14	1	11	7	4	2	2	11		N = 26

Code

Portuguese

- Q: Electric current intensity is quantity of charge flowing into an electric conductor/element per time unit.
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally.
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- I: *Intamo wa gwezi* (electric force)
- M: *Intsenko kumbe impimo wa gwezi yi phindsko ku ka wiela ya gwezi* (the quantity of electric current or electricity that pass through electric wire)
- D: Students claimed they know the meaning of the concept, but are only able to respond orally.
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.3: ANALYSIS OF QUESTION 6 (Insulator)

Insulator			Portuguese			Chope					
Personal information			Ideas			Ideas					
Student	Gender	Age	H	D	O	P	D	S	O	Comments	
C1	M	32	*			*				H-P	
C2	F	20		*			*				
C3	F	24			*				*	D-D	O-O
C4	M	23	*			*				H-P	
C5	M	37			*				-		O-"."
C6	M	--			*			*			O-S
C7	M	19	*						-	H-"."	
C8	M	21			*				-		O-"."
C9	M	21			*				-		O-"."
C10	M	26	*			*				H-P	
C11	M	21	*						-	H-"."	
C12	F	21	*			*				H-P	
C13	M	26	*				*			H-D	
C14	M	16			*				*		O-O
C15	M	28	*			*			*	H-O	
C16	M	16			*				*		O-O
C17	M	32	*						-	H-"."	
C18	F	21	*			*				H-P	
C19	M	27	*						-	H-"."	
C20	F	--			-/				-/	OUT	
C21	M	21	*			*				H-P	
C22	M	21	*					*		H-S	
C23	M	21	*					*		H-S	
C24	M	21	*						-	H-"."	
C25	M	22	*			*				H-P	
C26	F	--			-/				-/	OUT	
C27	M	34			*			*			O-S
C28	M	28	*						-	H-"."	
TOTAL			17	1	8	8	2	4	13	N = 26	

Code

Portuguese

- H:** Insulator is an instrument that hinders/obstructs passage of electric current
- D:** Students claimed they have no idea about the concept
- O:** Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- P:** *Insulator njimaha tchi phalelako guezi* (Insulator is an instrument/apparatus that hinders/obstructs passage of electric current)
- D:** Students claimed they have no idea about the concept
- S:** Students claimed they know the meaning of the concept, but are only able to respond orally
- O:** Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.4: ANALYSIS OF QUESTION 8 (Electric Power)

Electric power			Portuguese				Chope								
Personal information			Ideas				Ideas								
Student	Gender	Age	T	F	C	O	I	D	S	O	Comments				
C1	M	32				*			*					O-S	
C2	F	20		*	*		*						F-I	F-C	
C3	F	24				*	*							O-I	
C4	M	23				*					-			O-"-"	
C5	M	37		*			*						F-I		
C6	M	--	*									T-S			
C7	M	19	*								-	T-"-"			
C8	M	21	*								-	T-"-"			
C9	M	21				*					-			O-"-"	
C10	M	26	*				*					T-I			
C11	M	25				*			*					O-S	
C12	F	32		*			*						F-I		
C13	M	26	*				*					T-I			
C14	M	16				*			*					O-S	
C15	M	28	*				*					T-I			
C16	M	16	*				*					T-I			
C17	M	32	*				*					T-I			
C18	F	21		*			*						F-I		
C19	M	27		*	*						-		F-"-"	F-C	
C20	F	--				-/					-/	OUT			
C21	M	21	*					*				T-D			
C22	M	21		*	*			*					F-D	C-D	F-C
C23	M	21				*			*					O-S	
C24	M	21				-/					-/	OUT			
C25	M	22				*					-			O-"-"	
C26	F	--			*						-			C-"-"	
C27	M	34				-/					-/	OUT			
C28	M	28				-/					-/	OUT			
TOTAL			9	6	4	8	10	2	4	8				N = 24	

Code

Portuguese

- T: *Trabalho produzido por electricidade num determinado tempo* (work produced for electricity per time unit)
- F: *Força da energia electrica* (force of electric energy)
- C: *Capacidade de produzir energia* (Capacity of producing energy)
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/-")

Chope

- I: *Electric power *Intamo wa guezi** (electric power is electric force)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/-")

TABLE 4.3.5: ANALYSIS OF QUESTION 9 (Conventional current)

Conventional current			Portuguese				Chope					
Personal information			Ideas				Ideas					
Student	Gender	Age	P	C	D	O	T	D	S	L	Comments	
C1	M	32		*						*	C-L	Special note
C2	F	20	*					*			P-D	
C3	F	24				*				*		O-L
C4	M	23				-/				-/	OUT	
C5	M	37			*			*				D-D
C6	M	--				-/				-/	OUT	
C7	M	19		*						-	C-"."	
C8	M	21				-/				-/	OUT	
C9	M	21				*				-		O-"."
C10	M	26				*	*					O-T
C11	M	25	*					*			P-D	
C12	F	32			*			*				D-D
C13	M	26		*				*			C-D	
C14	M	16				-/				-/	OUT	
C15	M	28			*			*				D-D
C16	M	16	*						*		P-S	
C17	M	32	*				*				P-T	
C18	F	21				*			*			O-L
C19	M	27	*							-	P-"."	
C20	F	--				-/				-/	OUT	
C21	M	21		*				*			C-D	
C22	M	21	*						*		P-S	
C23	M	21		*					*		C-S	
C24	M	21		*						-	C-"."	
C25	M	22				-/				-/	OUT	
C26	F	--				-/				-/	OUT	
C27	M	34				-/				-/	OUT	
C28	M	28				-/				-/	OUT	
TOTAL			6	6	3	4	2	7	3	7	N = 19	

Code
Portuguese

- P: Conventional current is motion of electric charge from positive to negative pole
- C: Convention is agreement, before doing something
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- T: *Ku tsimbila ko hambana ka guezi in dane kati koti ta guezi* (Conventional current is an opposite motion to the real flowing of electric charge through electric conductor)
- L: *Corrente convencional yi guezi yɔ langana kumbe yo inguitsana* (Conventional current is current in agreement)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common idea are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.6: ANALYSIS OF QUESTION 10 (An electric circuit)

An electric circuit			Portuguese			Chope						
Personal information			Ideas			Ideas						
Student	Gender	Age	C	P	O	T	N	D	S	O	Comments	
C1	M	32		*		*						P-T
C2	F	20	*					*				C-D
C3	F	24	*							-		C-"."
C4	M	23		*		*						P-T
C5	M	37	*					*				C-D
C6	M	--			*	*						O-T
C7	M	19	*					*				C-D
C8	M	21			-/					-/		OUT
C9	M	21	*							-		C-"."
C10	M	26	*				*					C-N
C11	M	25	*						*			C-S
C12	F	32			*					*		O-O
C13	M	26	*			*						C-T
C14	M	16			-/					-/		OUT
C15	M	28	*			*						C-T
C16	M	16	*				*					C-N
C17	M	32	*				*					C-N
C18	F	21		*		*						P-T
C19	M	27			-			*				"-"-D
C20	F	--			*					-		O-"."
C21	M	21			*					*		O-O
C22	M	21	*						*			C-S
C23	M	21			*				*			O-S
C24	M	21			*					-		O-"."
C25	M	22			-/					-/		OUT
C26	F	--			-/					-/		OUT
C27	M	34			-/					-/		OUT
C28	M	28			-/					-/		OUT
TOTAL			12	3	7	6	3	4	3	6		N = 22

Code

Portuguese

- C: Electric circuit is an association OR connection of electric elements
- P: Electric circuit is a path of electric current
- O: Other responses (responses that are not stating common ideas are indicated as "-.", blank as "." and blank in both languages as "-/")

Chope

- T: *Electric circuit ngu tsangana kumbe ku lunghalhatelana kasigotso tsa guezi*
(Electric circuit is a association/ connection of electric elements)
- N: *Electric circuit ndzila ya guezi* (an electric circuit is a path aimed they know
the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "-.", a blank as "." and blank in both languages as "-/")

TABLE 4.3.7: ANALYSIS OF QUESTION 12 (Electric Current)

Electric current			Portuguese			Chope					Comments	
Personal information			Ideas			Ideas						
Student	Gender	Age	F	M	O	I	N	D	S	O		
C1	M	32			*		*					O-N
C2	F	20		*			*					M-N
C3	F	24			*	*						O-I
C4	M	23	*F					*			*F-D	
C5	M	37		*				*				M-D
C6	M	--	*						*		F-S	
C7	M	19	*F				*				*F-N	
C8	M	21			*		*					O-N
C9	M	21			-	*						"-I
C10	M	26			-	*						"-I
C11	M	25	*						*		F-S	
C12	F	32			*					-		"-O
C13	M	26	*			*	*				F-I	F-N I-N
C14	M	16			-					*		"-O
C15	M	28	*			*					F-I	
C16	M	16		*						-		M-"
C17	M	32	*			*	*				F-I	F-N I-N
C18	F	21		*			*			-		M-"
C19	M	27			-			*				"-D
C20	F	--			*					*		O-O
C21	M	21			-					-	OUT	
C22	M	21	*						*		F-S	
C23	M	21	*						*		F-S	
C24	M	21	*F							-	*F-"	
C25	M	22		*						-		M-"
C26	F	--			-					-	OUT	
C27	M	34			-					-	OUT	
C28	M	28			-					-	OUT	
TOTAL			10	5	9	6	7	3	4	7		N = 25

Code

Portuguese

- A: An electric current is a motion of electrons in one way/flowing of electrons
- *F: Students' responses are not completely correct
- M: An electric current is a motion of electric charge
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- I: *Electric current Insingá wa guezi* (Electric current is motion of electricity in one way OR is current of electric charges in one way)
- N: *Electric current Ndilo wa guezi* (an electric current is electricity)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.8: ANALYSIS OF QUESTION 14 (Parallel electric circuit)

Parallel electric circuit			Portuguese			Chope			
Personal information			Ideas			Ideas			
Student	Gender	Age	R	D	O	D	S	O	Comments
C1	M	32		*				-	D-"."
C2	F	20			*	*			O-D
C3	F	24						-/	OUT
C4	M	23	*			*			R-D
C5	M	37			*	*			O-D
C6	M	--		*		*			D-D
C7	M	19			-/			-/	OUT
C8	M	21			-	*			"-"-D
C9	M	21	*					-	R-"."
C10	M	26		*		*			D-D
C11	M	25			*		*		D-S
C12	F	32		*		*			D-D
C13	M	26	*			*			R-D
C14	M	16		*		*			D-D
C15	M	28			*	*			O-D
C16	M	16		*		*			D-D
C17	M	32			-			*	"-"-O
C18	F	21			*			*	O-O
C19	M	27			-	*			"-"-D
C20	F	--			-/				OUT
C21	M	21		*		*			O-D
C22	M	21			*		*		O-S
C23	M	21			*		*		O-S
C24	M	21			-/			-/	OUT
C25	M	22			-/			-/	OUT
C26	F	--			-/			-/	OUT
C27	M	34			-/			-/	OUT
C28	M	28			-/			-/	OUT
TOTAL			3	6	11	13	3	4	N = 20

Code

Portuguese

- R: PEC is electric elements associated/connected in the electric circuit, where all of them receive the same potential difference across their ends
 D: Students claimed they have no idea about the concept
 O: Other responses (responses that are not stating common ideas are indicated as "*" a blank as "-" and blank in both languages as "-/")

Chope

- D: Students claimed they have no idea about the concept
 S: Students claimed they know the meaning of the concept, but are only able to respond orally
 O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.3.9: ANALYSIS OF QUESTION 16 (Potential difference (pd))

Potential difference (pd)			Portuguese			Chope						
Personal information			Ideas			Ideas						
Student	Gender	Age	E	D	O	G	M	D	S	O	Comments	
C1	M	32			*		*					O-M
C2	F	20	*					*			E-D	
C3	F	24		*				*			D-D	
C4	M	23			*			*				O-D
C5	M	37	*					*			E-D	
C6	M	-			-					-	OUT	
C7	M	19			-					-	OUT	
C8	M	21			*					-		O-"."
C9	M	21		*						-	D-"."	
C10	M	26			-					-	OUT	
C11	M	25	*						*		E-S	
C12	F	32		*				*			D-D	
C13	M	26		*				*			D-D	
C14	M	16			-					-	OUT	
C15	M	28		*				*			D-D	
C16	M	16	*			*					E-G	
C17	M	32	*			*					E-G	
C18	F	21	*			*					E-G	
C19	M	27			*			*				O-D
C20	F	--			*					-		O-"."
C21	M	21			-					-	OUT	
C22	M	21	*					*			E-S	
C23	M	21	*					*			E-S	
C24	M	21		*				*			D-D	
C25	M	22			-					-	OUT	
C26	F	--			-					-	OUT	
C27	M	34			-					-	OUT	
C28	M	28			-					-	OUT	
TOTAL			8	6	5	3	1	9	3	3	N=19	

Code

- Portuguese**
- E: Potential difference is the difference in energy between two points
D: Students claimed they do not have any idea about the concept
O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

- Chope**
- G: *Potential difference Kuhambana ka intamo wa gaezi* (potential difference is difference of electric force or force of electricity)
M: *Potential difference Kuhambana ka matsimbilelo ya gaezi* (potential difference is difference of how the electricity or electric current is flowing)
D: Students claimed they have no idea about the concept
S: Students claimed they know the meaning of the concept, but are only able to respond orally
O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4. 3.10: ANALYSIS OF QUESTION 17 (Source of electromotive force (EMF))

Source of electromotive force (EMF)			Portuguese			Chope					
Personal information			Ideas			Ideas					
Student	Gender	Age	G	D	O	T	D	S	O	Comment	
C1	M	32	*			*				G-T	
C2	F	20			*		*				O-D
C3	F	24	*				*			G-D	
C4	M	23	*			*				G-T	
C5	M	37		*			*				D-D
C6	M	--			-/				-/	OUT	
C7	M	19			-/				-/	OUT	
C8	M	21			-/				-/	OUT	
C9	M	21			*		*				O-D
C10	M	26			-/				-/	OUT	
C11	M	25	*					*		G-S	
C12	F	32			*			*			O-S
C13		26	*			*				G-T	SPECIAL
C14		16			-		*				"-D
C15	M	28	*			*				G-T	
C16	M	16		*					-		D-"
C17	M	32	*					*		G-S	
C18	F	21	*			*				G-T	
C19	M	27	*					*		G-S	
C20	F	--			-/				-/	OUT	
C21	M	21			-			*			"-S
C22	M	21			*				-		O-"
C23	M	21			*			*			O-S
C24	M	21		*		*					D-T
C25	M	22			*	*					O-T
C26	F	--			-/				-/	OUT	
C27	M	34			-/				-/	OUT	
C28	M	28			-/				-/	OUT	
TOTAL			9	3	8	7	5	6	2	N = 20	

Code

Portuguese

- G: EMF is a generator of electric current
- D: Students claimed they have no idea about the concept
- O: Other responses (responses that are not stating common ideas are indicated as "*", blank as "-" and blank in both languages as "-/")

Chope

- T: *EMF tchissima/mdjisima tcha guezi kumbe ikadi yo bika indilo* (EMF is the well of electricity or electric current)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "**", a blank as "-" and blank in both languages as "-/")

TABLE 4.4.1: ANALYSIS OF QUESTION 2 (Voltmeter)

Voltmeter			Portuguese			Chope				Comments
Personal information			Ideas			Ideas				
Student	Gender	Age	V	A	O	M	D	S	O	
C1	M	32		*		*				A-M
C2	F	20	*						*	V-O
C3	F	24	*			*				V-M
C4	M	23		*			*			A-D
C5	M	37	*			*				V-M
C6	M	--	*					*		V-S
C7	M	19	*			*				V-M
C8	M	21		*			*			A-D
C9	M	21	*				*			V-D
C10	M	26	*			*				V-M
C11	M	25	*					*		V-S
C12	F	32			*				-	O-"."
C13	M	26	*			*				V-M
C14	M	16			*		*			O-D
C15	M	28		*		*				A-M
C16	M	16			*		*			O-D
C17	M	32	*			*				V-M
C18	F	21		*		*				A-M
C19	M	27	*				*			V-D
C20	F	--		*					-	A-"."
C21	M	21	*				*			V-D
C22	M	21		*				*		A-S
C23	M	21			*			*		O-S
C24	M	21	*						*	V-S
C25	M	22			*				-	O-"."
C26	F	--		*					-	A-"."
C27	M	34	*					*		V-S
C28	M	28	*						*	V-O
TOTAL			15	8	5	9	7	5	7	N= 28

Code

Portuguese

- V: Measures tension, voltage or potential difference (that are equivalent of words "tensao", voltagem and "diferença de potencial" respectively in Portuguese)
- A: Measures current intensity
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- M: *Mutchini uo thepa intamo wa guezi* (Apparatus used to measure electric force)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common idea are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.4.2: ANALYSIS OF QUESTION 5 (Interrupter)

Interrupter			Portuguese			Chope						
Personal information			Ideas			Ideas						
Student	Gender	Age	I	B	O	L	D	S	O	Comments		
C1	M	32		*		*				B-L		
C2	F	20			*	*						O-L
C3	F	24			*	*						O-L
C4	M	23		*		*				B-L		
C5	M	37		*		*				B-L		
C6	M	--		*		*				B-L		
C7	M	19		*				*		B-S		
C8	M	21		*		*				B-L		
C9	M	21		*					-	B-"."		
C10	M	26		*					-	B-"."		
C11	M	25		*		*				B-L		
C12	F	32		*			*			B-D		
C13	M	26	*			*					I-L	
C14	M	16		*		*				B-L		
C15	M	28		*			*			B-D		
C16	M	16		*					-	B-"."		
C17	M	32		*		*				B-L		
C18	F	21		*		*				B-L		
C19	M	27	*					*			I-S	
C20	F	--			-/				-/		OUT	
C21	M	21			*				-			O-"."
C22	M	21	*					*			I-S	
C23	M	21		*		*				B-L		
C24	M	21		*			*			B-D		
C25	M	22		*				*		B-S		
C26	F	--		*					-	B-"."		
C27	M	34		*				*		B-S		
C28	M	28		*					-	B-"."		
TOTAL			3	21	3	13	3	5	6			$n = 27$

Code

Portuguese

- I: Interrupter is an instrument used to open or close electric circuit
- B: Interrupter is an instrument used to switch bulbs on or off
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- L: *jimaha tchi tumelako ku laiha guezi/dilampada* (is something used to switch bulbs on or off)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

TABLE 4.4.3: ANALYSIS OF QUESTION 15 (Metal wire)

Metal wire			Portuguese			Chope							
Personal information			Ideas			Ideas							
Student	Gender	Age	E	M	O	W	G	D	S	O	Comments		
C1	M	32			-	*	*				"-"-W	"-"-G	W-G
C2	F	20			*		*						O-G
C3	F	24			*	*	*				O-W	O-G	W-G
C4	M	23			*	*							O-W
C5	M	37			*			*					O-D
C6	M	--			-	*							"-"-W
C7	M	19	*			*	*				E-W	E-G	W-G
C8	M	21			-		*						"-"-G
C9	M	21	*						*		E-S		
C10	M	26			*	*							O-W
C11	M	25	*						*		E-S		
C12	F	32	*			*	*				E-W	E-G	W-G
C13	M	26	*			*					E-W		
C14	M	16			-		*						"-"-G
C15	M	28	*			*	*				E-W	E-G	W-G
C16	M	16	*			*	*				E-W	E-G	W-G
C17	M	32	*			*					E-W		
C18	F	21		*		*						M-W	
C19	M	27			*			*					O-D
C20	F	--	*					*			E-D		
C21	M	21			-					-	OUT		
C22	M	21	*					*			E-D		
C23	M	21			*			*					O-D
C24	M	21		*						-		M-"-"	
C25	M	22		*		*						M-W	
C26	F	--			-					-	OUT		
C27	M	34			-					-	OUT		
C28	M	28			-					-	OUT		
TOTAL			10	3	11	13	9	5	2	1			N=24

Code

Portuguese

- E: Metal wire is an electric conductor
- M: Metal wire is wire, rope
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/')

Chope

- W: *Metal wire yi waiela/ngiti ya simbi kumbe didlocke da simbi*(metal wire is wire or "metal rope")
- G: *Metal wire yi Waiela ya guezi* (Metal wire is an electric conductor)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/')

TABLE 4.4.4: ANALYSIS OF QUESTION 18 (A battery)

A battery			Portuguese			Chope						
Personal information			Ideas			Ideas						
Students	Gender	Age	A	K	O	W	D	S	O	Comments		
C1	M	32	*	*		*				A-W	K-W	A-E
C2	F	20	*	*				*		A-S	K-S	A-E
C3	F	24		*					*		K-O	
C4	M	23		*		*					K-W	
C5	M	37	*				*			A-D		
C6	M	--				-		*				"-"-S
C7	M	19			*	*						O-W
C8	M	21			*				-			O-"-"
C9	M	21	*						-	A-"-"		
C10	M	26		*				*			K-S	
C11	M	25	*					*		A-S		
C12	F	32		*		*					K-W	
C13	M	26	*					*		A-S		
C14	M	16			-/				-/	OUT		
C15	M	28		*					*		K-O	
C16	M	16			*				-			O-"-"
C17	M	32	*			*				A-W		
C18	F	21	*	*				*		A-S	K-S	F-K
C19	M	27		*		*					K-W	
C20	F	--			-/					OUT		
C21	M	21			-				*			"-"-O
C22	M	21	*	*				*		A-S	K-S	F-K
C23	M	21	*					*		A-S		
C24	M	21		*			*				K-D	
C25	M	22			*				-			O-"-"
C26	F	--			*				-			O-"-"
C27	M	34								OUT		
C28	M	28								OUT		
TOTAL			10	11	7	6	2	8	8	N = 24		

Code

Portuguese

- A: A battery is an apparatus that is able to supply energy (electricity); electric force; it is an (electric)? accumulator
- K: I know what a battery is, but I do not know how to explain my understanding (knowledge); a battery is a capacitor, a cell, an apparatus used in cars or is a electric particle with certain electric capacity
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Chope

- W: *Nibatery difeko da guez* (A battery is an accumulator, is "warehouse" of electricity or electric current)
- D: Students claimed they have no idea about the concept
- S: Students claimed they know the meaning of the concept, but are only able to respond orally
- O: Other responses (responses that are not stating common ideas are indicated as "*", a blank as "-" and blank in both languages as "-/")

Author: Baquete, Aguiar Muambalane.

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