Mozambican University Students' Conceptions about the Relationship between Science-Technology-Society - Case study of the Pedagogical University

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Dedication:

In memory of my beloved Father João Pinto Madeira,

who showed me that education is the way

to free yourself and be a

citizen of the world.

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ABSTRACT

The problem that prompted this study is the absence of modern approaches and methods of teaching and learning science in Mozambican educational system. Currently, the science curricula in Mozambique can be characterized as: organized in separated disciplines, based on canonical science content, and teaching practices that are based on a teacher-centered approach using traditional methods of teaching.

On the other hand, there is an approach of teaching and learning which focus on the relationship between Science, Technology and Society (STS) that is well established in science education since the late 80s. This approach of teaching is claimed to be one of the best ways to achieve scientific literacy, promote decision-making and active citizenship of students in social issues pertaining the society where they live, and it had been used in many developed and developing countries.

Taking into account this discrepancy, and trying to find a solution for the problem the following research questions were posed:

1. What are Mozambican university students' views about the relationship between science, technology and society?
2. Does an STS approach of teaching involving inquiry type of laboratory work using an open-ended approach contribute to change students' views and beliefs about STS issues?
3. Could an STS approach of teaching be successfully implemented in Mozambican educational system at secondary and tertiary level?

In order to answer these questions and in a quest to find solutions for the problem posed a mixed-method approach was used, combining both qualitative and quantitative methods. There was a survey carried out in all branches of the Pedagogical University of Mozambique, covering all provinces of the country, and there was an intervention process implemented in iterative way in two tiers in two consecutive years.

The main instrument used to gather data, both in the survey and in the intervention process were 19 VOSTS item selected from a pool of 114 multiple choice items

developed in Canada in late 80s to assess students' "Views on Science - Technology - Society" (VOSTS). The 19 VOSTS items selected for the study, after translation from English to Portuguese were adapted and adopted as the main research instrument. The questionnaire administered to students both in survey and intervention consisted of 13 VOSTS items, of which only 7 were identical. The 6 VOSTS items used in the survey were focusing on views of science in medias and science class and aspects related to the technology development and implementation, while the 6 other different used in the intervention process were focused on the nature of science (epistemology).

The survey was carried out by administering the 13 VOSTS items questionnaire in all ten provinces of the country with branches of the Pedagogical University, using 832 second year students enrolled in four science or science related courses of: agriculture, biology, chemistry and physics. The aim of the survey was to establish a baseline situation of the country about STS issues, since the study was the first of its kind in the country.

The intervention process was made in two tiers in two consecutive years, involving 59 second year chemistry students of one branch. The intervention process was implemented in 12 weeks and the design consisted of four different stages: (1) pretest, consisted of administering the 13 VOSTS items questionnaire; (2) seminars about STS issues, STS approach, and about inquiry type of practical work using open ended approach; (3) students performing experiments to solve problems posed using the knowledge about STS issues. During this process field notes and some videotapes were made; (4) post-test at the end of the process using the same instrument administered in the pretest, and (5) post-intervention interview with selected students who participated in the study to evaluate the process in which they were involved.

To assess students' responses to the questionnaires administered both in the survey and in the intervention, a panel of 10 experts was assembled as judges, all of them university lecturers with PhD Degree and more than 15 experience teaching biology (1), chemistry (5), physics (1); mathematics (3) and French teacher (1). Their task was to categorize the options of each VOSTS statement and classify as ***Realistic***, and other options could be classified as many times as possible as ***Has Merit*** or ***Naïve***. The last three options that were common to all VOSTS items were considered ***Passive***. After analyzing the classifications of every expert, an effort was made to find consensus and come up with one final categorization that could be used a scoring scheme to assess students' responses to the questionnaire. In those VOSTS items where there were discrepancies in selecting the Realistic view it was solved by adopting categorization made in other studies using the same VOSTS items made by people acquitted with STS issues, unlike the experts used in this research (only one was acquitted with the approach). G

The underlying assumption in this study is that the ultimate goal of science teaching is to change students' opinions progressively ñfrom Naïveò to ñHas meritò, and from there to a ñRealisticò view about the relationship between science, technology and society. Taking this into consideration the following conclusions were inferred:

1. Mozambican students' views and beliefs about the relationship between science, technology and society are positive, they correspond to what is commonly accepted in the scientific community about the STS issues assessed in this study.

2. The results from the baseline study, besides being considered positive showed that students irrespective of the course that they are enrolled (agriculture, biology, chemistry and physics), have no significant difference on the STS issues assessed.

3. An STS approach of teaching implemented through inquiry type of practical work using open ended approach during twelve (12) weeks suggests that students' views are positive and are more in line with what is accepted in the scientific community about the 13 VOSTS items assessed in the intervention process.

4. Based on the results of the intervention process with the experimental group in two different years it can be concluded that the STS approach of teaching proposed and implemented though inquiry type of practical work using open ended approach did not contributed to change students' views and beliefs about STS issues from pretest to post-test, except in two of the 13 VOSTS items assessed.

5. By comparing students' responses to the seven common VOSTS items in the baseline study and in the intervention process, in both years and pretest and post-test, the answer pattern are similar. These findings show, on one hand that all science students share the same views about science, and on the other hand that irrespective of the intervention made students did not change their views.

6. Based on the results of the baseline study, the results of the intervention process and taking into account the evaluation of the blue print documents about Mozambican educational system and the socio-politic context of the country it can be concluded that the STS approach of teaching can be implemented in Mozambique.

Finally, it is worthy to consider that taking into account the study design made, the sample size used, and the rigor in controlling variables, it is believed that the results of this study are valid and can be generalized to other Mozambican students with the same science background. Furthermore, when considering science as universal irrespective of the place where it takes place, some of the findings of this study can be generalized to other places in world.

Zusammenfassung

In einer sich ständig veränderten Gesellschaft, in der naturwissenschaftliches Wissen und die Produkte von Naturwissenschaften und Technologie in nahezu allen Aspekten modernen Lebens vorhanden sind, ist es wichtig, Bürger zu haben, die in der Lage sind, diese Aspekte zu verstehen und mit ihnen umgehen zu können und dabei informierte Urteile in lebensnahen Situationen in der Gesellschaft machen zu können.

Das übergeordnete Ziel jeglicher Bildungssysteme auf der Welt ist es, Schüler und Studenten auszubilden, die an sozialen Prozessen aktiv teilnehmen können und eine sogenannte Äscience literacyñ entwickeln. Es bestehen viele Probleme hinsichtlich des Lehrens und Lernens von Naturwissenschaften wie zum Beispiel: Stures Auswendiglernen, abnehmendes Interesse an Naturwissenschaften und naturwissenschaftlich nahestehenden Kursen nach dem Beenden der Schulzeit. Unter Berücksichtigung dieser bestehenden Probleme des Lehrens und Lernens von Naturwissenschaften sind viele unterschiedliche Programme und Kurse auf der Welt entwickelt worden, um die Schwierigkeiten zu überwinden. Ein solcher Ansatz ist der Science-Technology-Society (STS) Ansatz, der auf konstruktivistische Ideen und Prozeduren setzt und als einer der besten Wege angesehen wird, die Probleme anzugehen zu überwinden. Der Ansatz entstand zuerst in Kanada in den neunziger Jahren desletzten Jahrhunderts.

Seit dieser Zeit sind viele STS-Ansätze des Lehrens und Lernens in zahlreichen entwickelten und unterentwickelten Ländern konzipiert worden, hauptsächlich mit dem Ziel, a) Naturwissenschaften für alle zu entwickeln, b) Äscience literacyñ zu erreichen und c) die Teilnahme auch von benachteiligten Schülern an naturwissenschaftlichem Unterricht in den Schulen zu verbessern. Obwohl es einige Kritik zur Effektivität des Lehrens der Naturwissenschaften gibt, wird seine Relevanz im naturwissenschaftlichen Leben und Lernen nicht infrage gestellt, und die Mehrzahl forschungsbasierter Ergebnisse unterstützt die Annahmen, die zum STS Ansatz gemacht wurden.

Das hauptsächliche Charakteristikum zu den naturwissenschaftlichen Curricula in Mosambik ist es, dass sie als getrennte Disziplinen organisiert sind, auf einem

kanonischen Wissensbestand von Naturwissenschaften basieren und dass die Lehrmethoden auf lehrerzentrierten Ansätzen mit dem Gebrauch traditioneller Methode des Lehrens Lernens beruhen. Gegründet auf die Vorzüge, die man STS Ansätze im Lehren und Lernen von Naturwissenschaften zuschreibt, und unter in Betracht ziehen der Besonderheiten mosambikanischer Naturwissenschaftscurricula war es der Zweck dieser Arbeit, forschungsbasierte Nachweise zu erheben, um die Einführung dieses Ansatzes im Land Mosambik vorschlagen zu können.

Diese Arbeit wurde ausgeführt, um die Bedingungen und die Möglichkeiten einer Implementierung eines STS-Ansatzes mit besonderer Fokussierung auf eine ihrer lehrerbildenden Einrichtungen (Pädagogische Universität Maputo, Provinz Manica, Abteilung Chimoio) zu erforschen. Zu diesem Zweck wurde zunächst eine ausführliche Literaturrecherche durchgeführt, um Referenzen, die auf dem STS-Ansatz basieren, offene Fragestellungbei praktischer Laborarbeit beinhalten und die Förderung eines Konzeptwechsels von Lehramtsstudierenden an der Universität anstreben, zu erarbeiten. Unter Berücksichtigung oben genannten Probleme und dieses theoretischen Gerüstes waren die folgenden Forschungsfragen anzugehen:

1. Welche Ansichten haben die mosambikanischen Universitätsstudenten in Bezug auf den Zusammenhang zwischen Naturwissenschaften, Technologie und Gesellschaft?
2. Kann ein STS-Ansatz, der praktisch Laborarbeit mit offenen Fragestellungen und Aufgaben dazu beitragen, die Ansichten der Studierenden über STS-Probleme verändern?
3. Könnte ein STS Ansatz zum Lehren und Lernen in die Lehrerbildungseinrichtungen und Sekundarschulen in Mosambik erfolgreich implementiert werden?

Um diese Fragestellungen anzugehen, wurde ein Ansatz bestehend aus qualitativen und quantitativen Methoden konzipiert. Er bestand aus einer Basisstudie, einem quasi-experimentellen Ansatz mit einer Projektgruppe und der Triangulation von den Methoden. Methodisch kann der Forschungsansatz in drei Teile aufgeteilt werden: eine Pilotstudie, einer Grundstudie mit allen Studierenden und einer Interventionsstudie (dem experimentellen Ansatz). In allen drei Teilen wurde das VOSTS- Instrument (ĂViews on Science, Technology and Societyñ) eingesetzt, ursprünglich von Aikenhead in Kanada entwickelt, bestehend aus einem Pool von 114 Items, eingesetzt um die Ansichten und Überzeugungen von Studierenden zu STS zu erheben.

Aus dem VOSTS-Fragebogen-Instrument wurden 19 Fragestellungen ausgewählt und aus dem englischen ins portugiesische übersetzt. Sie wurden an der Hochschule in Beira im Rahmen der Pilotstudie mit Studierendeneingesetzt, die die gleichen Charakteristika wie die Zielgruppe, die für die Intervention ausgewählt worden war, hatten. Die Pilotstudie hatte das Ziel, die Tragfähigkeit des Instruments im Kontext des Landes Mosambik festzustellen und die Anzahl der Fragen auszuwählen, die anschließend in einem Fragebogen an die Gruppe der Studierenden aus dem Grundstudium und der experimentellen Gruppe, die an der Intervention teilnahm, eingesetzt werden sollten.

Die hauptsächlichen Ergebnisse der Pilotstudie waren: 1. Die Anzahl der VOSTS Items musste von ursprünglich 19 auf 13 reduziert werden, um die Zeit, die für die Beantwortung der Fragestellungen durch die Studierenden benötigt wurde, auf einen Rahmen von 60 bis 90 Minuten zu begrenzen. 2. Es bestand bei der Einführung des Fragebogens die Notwendigkeit, den Studierenden zu erklären, wie damit um damit umzugehen sei, weil die Fragestellungen ziemlich komplex aufgebaut sind, einige bestehen sogar aus zwei Teilen, und die Studierenden gefragt waren, jeweils nur eine einzige Option aus dem Feld der vorgegebenen möglichen Ansichten anzugeben, die am besten mit ihre eigenen Meinung übereinstimmten.

In der Basisuntersuchung wurde der Fragebogen in allen zehn Abteilungen der pädagogischen Universität eingesetzt, es wurden 832 Studierende aus dem zweiten Studienjahr mit den Fächer Biologie, Chemie, Physik und Landwirtschaft einbezogen.

Es wurde mit der experimentellen Gruppe eine praktische Intervention konzipiert, die einen Zeitbedarf von zwölf Wochen an der Universität umfasste und individuelle Projektarbeiten der Studierendenaus dem 2. Studienjahr der Chemie zu einem STS-Problem beinhaltete. Die Studierenden arbeiteten jeweils in Gruppen von vier. Diese Interventionen wollten zweimal in den Jahren 2012 und 2013 durchgeführt, die Arbeiten im Labor wurden durch teilnehmende Beobachtung und Videoanalyse evaluiert. Die

Ergebnisse aus dem Jahr 2012 wurden dazu benutzt, die vorgesehenen Arbeiten des Jahres 2013 in einem iterativen Prozess zu modifizieren. Es gab keine Kontrollgruppe. Bevor die Intervention stattfand, um die Studierenden mit den neuen Ansätzen im Lehren und Lernen vertraut zu machen, mit denen sie konfrontiert werden sollten, gab es ein Training zu STS-Problemen und zum Umgang mit den offenen Fragestellungen beim praktischen Arbeiten im Labor. Außerdem wurde vor der Intervention im Labor der Fragebogen mit 13 ausgewählten VOSTS Items eingesetzt. Die praktischen Arbeiten nach dem STS-Ansatz mit offenen Laborarbeiten fanden in einem Schullabor nahe der Universität statt. Die teilnehmende Beobachtung umfasste Notizen des Projektleiters und Videoaufzeichnungen von ausgewählten Elementen. Nach Ende der praktischen Intervention wurden zwölf Studierende für Interviews ausgewählt, jeweils sechs aus jedem Jahr.

Um die Antworten der Studierenden aus dem Fragebogen bewerten zu können, die in der Grundstudie und in der Interventionsstudie erhalten wurde, wurde ein Bewertungsraster entwickelt. Um es zu erstellen, wurden sechs Experten ausgewählt, die alle einen Doktortitel in Naturwissenschaften bzw. in Didaktik der Naturwissenschaften hatten, und mit mehr als 25 Jahren Erfahrung als Dozenten in den jeweiligen Disziplinen (vier aus der Chemie, einer aus der Biologie und einer aus dem Fach Physik). Von diesen sechs Experten war nur einem den STS Ansatz von vornherein bekannt, die anderen fünf nicht, hatten aber ein tiefgehendes Wissenschaftsverständnis im jeweiligen Fachgebiet.

Aus der Basisstudie ging hervor, dass es keine signifikanten Unterschiede in den Antwortmustern über alle 13 Fragestellungen gibt, dies gilt ebenso für alle vier unterschiedlichen Fachrichtungen. Dies bedeutet auch, dass es kein typisches Antwortmuster gibt, die einen bestimmten Kurs von einer der zehn beteiligten Abteilungen, denen die Studierenden angehörten, gibt. Aus der Beurteilung der studentischen Antwortmuster und deren Einordnung in drei Kategorien, die entwickelt worden waren, kann geschlossen werden, dass im allgemeinen die studentischen Ansichten und Überzeugungen weitgehend positiv eingeschätzt werden können, weil die Mehrheit ihrer Auswahlen in die Rubriken Ăhas meritñ, einige als Ărealisticñ (der idealen

Kategorie) eingeschätzt werden können, nur wenige in die Kategorie Ănaiveñ Außerdem konnte im Vergleich von Basisstudie und Interventionsstudie kein signifikanter Unterschied festgestellt werden.

Aus den Ergebnissen mit den Expertengruppen aus zwei Jahren kann geschlossen werden, dass die studentischen Überzeugungen zu STS sich nicht signifikant zwischen einem Post einen Drehtest und einem Posttest unterscheiden, mit Ausnahme zwei der 13 Posts Items. Aus diesen Ergebnissen kann gefolgert werden, dass die Intervention Studie entgegen dem angenommenen Konzept schon Challenge keine Veränderungen bewirkte. Offenbar sind die bereits bestehenden Konzeptionen der Studierenden über STS Fragestellungen so tief verankert, dass die Zeitdauer der Ansatz, die für die Intervention angesetzt waren, nicht zu einer Veränderung ausreichte. Darüber hinaus kann aber festgestellt werden, dass die allgemeine Einschätzung der Studierenden in Pretest und Posttest insgesamt positiv blieb, weil die Einschätzungen "has merit, realistic und naive" sich in der Zusammensetzung nicht änderten. Darüber hinaus kann auch festgestellt werden, dass die Ansichten der Studierenden sowohl in der Basisstudie als auch in der Interventionsgruppe sehr ähnlich waren, es konnten keinerlei signifikanten Differenzen beobachtet werden.

Die zugrunde liegende Annahme in dieser Arbeit war es, dass es das übergeordnete Ziel von naturwissenschaftlichem Lehren und Lernen ist, die Ansichten von Studierenden zu den Zusammenhängen zwischen Wissenschaft, Technologie und Gesellschaft im Laufe der Zeit von Ănaiveñ über Ăhas meritñ zu Ărealisticñ zu entwickeln. Obwohl die Auswertung aller studentischen Antwortmuster, erhoben in der Basisuntersuchung und in den Interventionsgruppen, als überwiegend positiv eingeschätzt werden kann, besteht nach wie vor eine Notwendigkeit, deren Vorstellungen und Überzeugungen so zu verbessern, dass sie die in höherem Maße dem entsprechen, was in der Gemeinschaft der Wissenschaftler akzeptiert ist.

Nimmt man alle Ergebnisse aus der Untersuchung sowie der Literaturstudie zum STS-Ansatz und den Kontext des Landes Mosambik zusammen, so lässt sich feststellen, dass genügend Nachweise vorliegen um zu sagen, dass der STS-Ansatz erfolgreich in das Bildungssystem von Mosambik eingeführt werden könnte, speziell in die lehrerbildenden Einrichtungen. Schließlich, obwohl die Studie hauptsächlich an einer spezifischen Abteilung der Pädagogischen Universität Maputo durchgeführt wurde, ist der Autor überzeugt, dass das Interventionsdesign, die Untersuchungsgröße und die Kontrolle der Variablen valide ist und daher der Ansatz generalisiert werden kann auf Studierende mit ähnlichem naturwissenschaftlichen Hintergrund in Mosambik übertragbar ist.

Chapter I: INTRODUCTION

The aim of this chapter, as an introductory chapter, is to give an overview about the whole thesis. It presents personal and professional reasons to study the topic, the statement of the problem that motivated this thesis, the objectives of the research, the research questions and finally the outline of the thesis.

The Personal reasons for doing research on this topic are based on three situations or episodes related to my past and current academic activities:

1. Twice researched about school laboratory experiences at undergraduate level (BSc Honours in 1993) and at post-graduate level (MSc 2005). In both cases the research topic was focused on practical work by suggesting solutions for the problem of lack of school laboratories in the majority of Mozambican secondary schools or motivate teachers to do practical work by all means including the use of micro science kits in Mozambican secondary schools.
2. Since I became junior lecturer in 1993 I always worked in two areas - didactic of chemistry and history of chemistry. By working in these two field I became interested to investigate more about how scientific knowledge is build throughout different historic periods and the impact of science and technology on the society. These issues are well covered by the STS approach of teaching.
3. After ten years as junior lecturer I was Master student in 2004, at the University of Witwatersrand in South Africa where I had Science, Technology, and Society (STS) as one of the modules of the course. Since then I became interested on the topic, although I have never explicitly applied it because the issue is not part of our curriculum at the Pedagogical University. So, when comes an opportunity to pursue my studies at the PhD level it was an opportunity to study a topic that I like and I am committed to introduce in Mozambique.

Based on this personal reasons to research about STS approach, below the research problem is identified and analyzed setting ground for further steps of the research.

1.1. Statement of the Problem

Clearly the main purpose of this study is to introduce the STS approach in Mozambican educational system. The main reason for that is because the STS approach is one of the most important trend in science education, and despite that it has never been heard by the overwhelming majority of Mozambican university students, and thus has never been applied in senior secondary school and at teacher training institutions.

The rationale for studying STS approach of teaching and learning is two-fold: first, recent trends in science education, according to Paixão et al. (2008), STS is among the eleven research lines most researched and published in the three most important international Science Education Research (SER) journals: *Science Education (SE), Journal of Research in Science Teaching (JRST)* and the *International Journal of Science Education (IJSE)*. Second, STS is an unexplored area in Mozambican system of education. In fact, despite all the recognized importance and being used widely throughout the world, STS is still unknown for the overwhelming majority of pre-service teachers and is not a component of any curricula of institutions that train teachers or any other tertiary institution in Mozambique.

Every citizen as human being and social being has the right to education, and education is key to success of any society. Despite that, in most African countries, including Mozambique, education is still regarded as passing through various institutions of learning and get papers that certify the learners to be employed or to be recognized by the society.(Tichapondwa, et al., 2013). This reductionist view of education neglects the vast potential of other sources of knowledge in society available to all people simply because they are social being.

The educational system of Mozambique is designed in such a way that science curricula is integrated in primary school, and it is separated science - biology, chemistry and physics at junior and senior secondary school. In both cases the curricula do not reflect the cultural and context of the country as pointed out by Ogunniyi, (1988; p.1). *"most science curricula in Africa are modeled on those in west and hence do not reflect cultural background of the learner."*

The relationship between science, technology and society is an academic field within science education and a social movement. In either situation STS approach should be implemented in Mozambican educational context for several reasons and they include the following.

1. Science curriculum at junior and senior secondary school is traditional and it is the initial level of organization of science courses in a school or university. The basic teaching characteristics are:

- traditional organization of curriculum, mostly an oral explanation of concepts, theories and laws;
- a traditional methodology of examinations, based on recall of factual information;
- a lack of application of modern educational computer software and educational technology;
- a traditional type of organization of science educational laboratories;
- Teachers working on this level frequently are rarely familiar with the modern pedagogical literature (books and articles) and, of course, can not apply these results in the design of the course.

In spite of this traditional way of organization of science curricula, the country has launched a long term curriculum reform that advocates the use of modern learning theories, featuring more learner-centered, outcome-based, based on development of competencies, and reserve 20% to treat local issues termed "local curriculum." (MINED, 2008).

There is a theoretical framework supporting and highlighting the use of STS approach when it is acknowledged that "é .the research literature is unambiguous concerning the positive outcomes in students learning in STS science classroom.ò (Aikenhead, 2005, p.10).

The curricular plan for secondary school outlines explicitly what is expected in the area of mathematics and natural science with regard to the STS approach proposed in this study (MINED, 2007; p.43):

> *"In this area will be developed competencies that will allow the learner to understand basic concepts of science, develop abilities, strategies, and habits of scientific research and communicate it as well as how to relate science with technology, society and environment."*

In practical terms the introduction of STS approach of teaching can be one step forward to overcome the traditional way of organization of science curricula, because of the good features of this approach as presented by Aikenhead (2005, p.8):

> *ñGood science-technology-society science education is relevant, challenging, realistic, and rigorous. STS science teaching aims to prepare future scientists/engineers and citizens alike to participate in a society increasingly shaped by research and development involving science and technology.ò*

From the reasons above presented it is clear that, if not for well documented examples of implementation of a STST approach of teaching, at least theoretically what it is advocates about this approach it is seemingly the best solutions for the current dissatisfaction with the science curricula.

2. As a developing country Mozambique has little scientific and technological development. Despite that, as part of global market the country is exposed to many technological products and benefits from the scientific advancements produced elsewhere. About the far reaching impact of technology and science in Africa Jejede & Bello (1988, p.401) referred about Nigerian context:

> *"Even the remotest settlements come in contact daily with the products of modern western technology in one form or another, either through the use of radios, trucks, medicines, chemical fertilizers, or other essentials."*

The same situation is applicable to Mozambique where more than 60% of the population live in rural area. The authors moved on by describing the instability of African governments:

> *"A feature of the developing world is that of instability of government that in turn hampers the total national development in which science and technology play important roles. STS is an effective outlet for the transmission of information on science and technology and their impact on the daily lives of the people."* (Jejede & Bello, 1988, p.401).

From the two statement above presented it can be inferred that STS approach can be viewed as social movement where scientific and technological issues are experienced by all citizens.

3. The ministry of Education of Mozambique advocates the use of 20% of the allocated time of each subject with local content on issues that are relevant and meaningful for the learners. An STS approach of teaching may be a great opportunity to fulfill this recommendation, as pointed out by Jejede and Bello (1988, p. 401):

> *"Harnessing the remains of the indigenous technology of say, tanning, craft, painting, hunting, communication, etc., with a view to integrating them with modern technology requires a course like STS to provide a forum that involves the discussion of science and technology far beyond their facts and principles."*

The perspective presented is of an STS approach inspired on social problems and integrate them into the formal curriculum to make the learning process meaningful and context-based.

Overall the implementation of an STS course in Mozambique seem to be the way forward, because:

"Nigeria (Mozambique likewise) cannot afford to neglect the contemporary shift in science curricula that promises to be of special benefit to the developing world and is a likely panacea to a lot of the problems therein." (Jejede & Bello, 1988, p. 402):

It is the contention of this proposal that the STS approach should be introduced in Mozambique first at teacher training institutions rather than at secondary school. The main reason for that is two-fold: first, most of minister's of education workers who frequently attend graduate and post-graduate courses at Pedagogical University, as police makers may influence the introduction of this approach of teaching once exposed to it and get a sense of its advantages. Second, primary and secondary school curricula are under constant change to meet some regional (SADC) and international (UNESCO) requirements that the introduction of this approach would not have the desired long term effect.

In summary the main problem posed and to be studied in this research is the discrepancy between what is observed in Mozambique: a science curricula structured according to canonical science and taught based on traditional methods, while there exist more effective and modern approaches and methods of teaching and learning science. The STS approach is one of such modern approaches and it is the intention of this study to introduce it in Mozambican educational system.

While a variety of definitions of STS (Science-Technology-Society) have been used with different meanings, this thesis will use the definition suggested by Aikenhead (1994, p.52):

> *"STS approaches are those that emphasize links between science, technology and society by means of emphasizing one or more of the following: a technological artifact, process or expertise; the interactions between technology and society; a social issue related to science or technology; social science content that sheds light on societal issue related to science and technology; a philosophical, historical, or social issue within the scientific or technological community. "*

According to this definition it can be inferred that STS approaches stretches its boundaries beyond the object of study-specific of natural sciences disciplines and incorporate other areas such as philosophy, sociology, history and anthropology.

1.2. Objectives of the Research

General objective:

To evaluate the conditions and possibilities to introduce of an STS approach of teaching and learning in Mozambican educational system, with special focus on university at teacher training institution.

Specific objectives:

1. To verify Mozambican university students conceptions about the relationship between science, technology and society.
2. To establish whether an STS approach of teaching done through experiments using open-ended and inquiry type of tasks contributes to conceptual change about STS issues.
3. To determine how an STS approach of teaching could be implemented in teacher training institutions in Mozambique.

1.3. Research Questions

The above objectives were translated into the following research questions which guided the study to solve the problem posed:

1. What are Mozambican university students' viewsabout the relationship between science, technology and society?

2. Does an STS approach of teaching involving inquiry type of laboratory work using open-ended approach contribute to change students' views and beliefs about STS issues?

3. Could an STS approach of teaching be successfully implemented in Mozambican educational system at secondary and tertiary level?

In order to answer these questions the following methods and procedures will be used:

1. Administering a questionnaire to all second year students enrolled in science courses: biology, chemistry and physics and science related course - agriculture, in all branches of the Pedagogical university in Mozambique.

2. Designing and applying an intervention in two tiers (2012 and 2013), having as target group second year pre-service chemistry teachers. During the 12 weeks of intervention process the STS approach was implemented through open-ended and inquiry type of practical work. Participant observations and video recording of the lessons documented what happened in a learning environment. After students responding to pre and post-test questionnaire there was a post-intervention interview to evaluate the intervention made.
3. Evaluating the results of both the diagnostic study and the intervention made to make inferences about the prospect of introducing an STS approach in Mozambican educational system.

The baseline study was made in 2011 having as a target population of 832 students taking the second-year offering biology, chemistry, physics and agriculture from all 10 branches of the Pedagogical University. The intervention process lasted twelve weeks and was made in two tiers, first in 2012 and second in 2013, both using second year chemistry students from one of the branches.

Overview of Chapters

Altogether, the thesis comprises eight chapters. A brief summary of each one is given below.

Chapter I: **Introduction**. It presents personal and professional reasons to carry out the study of this topic, it continues by presenting the statement of the problem that motivated to do this study, states the aims of the research, and poses the hypothesis to be verified in order to give solution to the problem posed.

Chapter II: **Background about the Country**. It gives an overall background of Mozambique, the country in which the research will be carried out. It emphasizes physio-geographic characteristics, socio-economic and socio-politic features as well as the educational system of the country.

Chapter III: **Theoretical Background**. It presents a summary of literature review of different aspects discussed in the research, ranging from STS approach of teaching, importance of laboratory work for science teaching and learning, and the development of science process skill. science teaching and learning, and the development of science process skill.

Chapter IV: **Research Methodology**. It gives the research paradigm underpinning the approach used to solve the problem posed, as well as the methods and techniques used to collect the data to verify the research questions and achieve the aims of the research.

Chapter V: **Results and Discussion of Data from the Survey**. It presents, discusses and analyzes data gathered from the administration of a questionnaire nationwide in all 10 branches of the Pedagogical University in Mozambique. The questionnaire was administered in order to have a baseline situation to compare the views of students from the intervention group with the views of all students enrolled in the natural sciences and agriculture

Chapter VI: **Results and Discussion of Data from the Intervention**. It presents, discusses and analyzes data from the intervention made using the proposed teaching approach. It gives a description of the learning environment where students were performing practical work, the results of pre and post-test, post-intervention interviews, and triangulation of the data to make inferences about the outcome.

Chapter VII: **Discussion and Directions**. It brings together the results of different chapters and discusses them in light of the aims of the research and the research questions. In addition to that it shows the directions to take for further research building up on the findings of this study.

Chapter VIII: **References**. It gives a list of all sources of information cited throughout the text. It includes books, journals, websites, reports, and blue print documents from some institutions.

Appendixes: is made of selected VOSTS items that comprised the administered questionnaire both in baseline study and in the intervention process. In addition to that it presents the seminars given to students about STS issues and about inquiry type of practical work using an open-ended approach. It also presents the output of the statistical analysis made to the survey and pre and post-test, as well as students' answers to the post-intervention interview.

Chapter II: BACKGROUND ABOUT THE COUNTRY

Having presented an overview of the thesis by stating the rationale for doing this thesis, presenting the problem, and the aims of the research this chapter proceeds by giving an overview about the context of the country in which the research takes place.

The aim of this chapter is to present some characteristics of Mozambique. It seeks to give an overview about the contexts in which the study was carried out, by describing the political and socio-economic situation of the country, which in some extend affects the educational system. By doing so, it is expected that one can make sense of the specific teaching and learning approaches chosen in this study. Overall it is expected to give the singularities of the country.

The chapter starts by giving socio-political situation of the country, and the international obligation to fulfill. Then presents the education structure of the country, the patterns of secondary school and university curriculums. Finally it presents the implication of all these to the study by outlining the six (6) key features of the country.

2.1. Socio-politic Context

Mozambique is a country with an area of 799.380 Km^2,(MINED, 2012) situated on south east cost of the African continent. It is bordered by six (6) countries, all English speaking, distributed in the following way: in north by Tanzania, Malawi and Zambia in north-west, Zimbabwe in West, Swaziland in south-west and South Africa in south-west and south and in the east by the Indian Ocean with more than 2477 Km coast long from north to south of the country with about 2000 miles sea coast of what is called the Mozambique Channel. (See the political Map of Mozambique with its' 11 provinces). The country is member of an economic region called Southern African Development Community (SADC), along with other 14 state members of this organization with an estimate population of 250 millions.

Below it is presented the map of Africa with Mozambique and countries with which it shares borders:

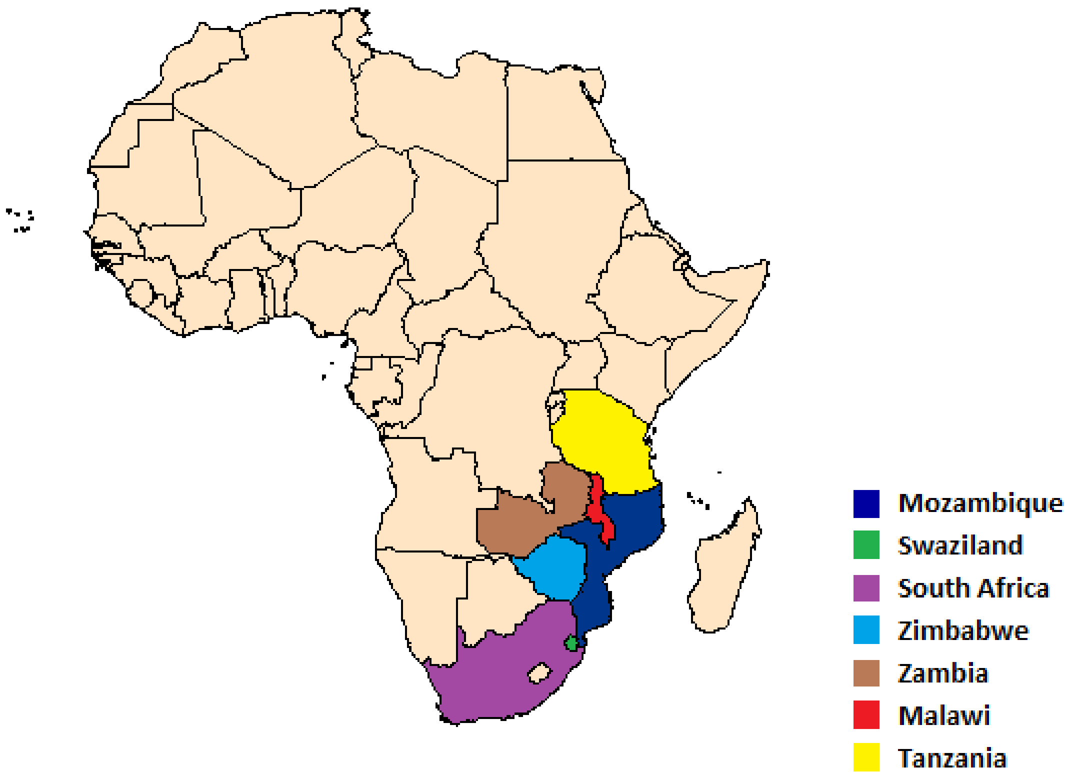

Figure 1: Map of Africa with Mozambique and countries with which it shares borders

The country gained its independence in 1975 - from Portugal and in the same year became Republic and adopted the socialist system of governance. The benefits of independence from the colonialism did not last long, couple of years after, in 1977 the country underwent a civil war that lasted 16 years, ending in 1992, with the signature of peace agreement. Before that, in 1990 the constitution was changed introducing the multiparty system, and held its first democratic and multiparty elections in 1994, and in 1998 the country held its first municipal elections.

Mozambique is a multicultural and multilingual country with more than 17 local languages, the majority of them of Bantu origin. Although there are programs to promote these languages - since the independence the official language used is Portuguese, and so far is the only language of instruction used at secondary and tertiary level.

According to the projections of the last population projection in 2015 carried out by the National Institute of Statistics (INE), Mozambique has in 2015 an estimated population of 26.423.623 of which 52% are female and 48% male , and 67.9% live in rural area, and 32.1% in the urban area (National Statistic Institute 2015).

Mozambique is a developing country, with some of socio-economic indicator below the average of other sub-Saharan countries, thus it is striving to improve to relief the extreme poverty that affects about 54% of the population (INE, 2015). The main sector of activity is agriculture and fishery, practiced by more than 75% of the work force. Only 20% of the population are included in the banking system.

2.2. International Commitments

As an independent country and member of many international organizations, such as SADC (15 member states from Southern Africa) and United Nations (UN) through its many agencies, the country tries to engage in multiple programs to meet international goals, of that is worth to present four (4) of them:

First, to attain most of the Millennium Development Goals (MDG), set up to be accomplished by 2015, and especial emphasis is given to:

1. Goal 1: poverty eradication - currently more than 54% of the population lives in absolute poverty (earning an equivalent to less than $ 1,5 USD/day/person). The country also aims to improve its position in the Human Development Index annually released by the United Nations Development Program (UNDP) - currently it is rated among the 5 poorest countries in the world in position 165 of the 170 countries assessed (INE, 2012).
2. Goal 2: achieve universal primary schooling - currently the enrolment rate is about 90% and the primary completion rate is 78%. The ratio teacher/student is 1/55 in primary school; 1/38 in secondary school, 1/16 in technical schools and 1/15 in higher education institutions (MINED, 2009).
3. Goal 4: reduce the mortality rate of children under 5 years - currently the country has more than 78 deaths per 1000 new born. There is one medical doctor for about 30 thousand people, and one nurse for 10.000 people in a country with a life expectancy of 53 years (INE, 2012).
4. Goal 5: reduce the maternal mortality - currently more than 100 women die per 1000 service delivery (INE, 2012).
5. Goal 6: reduce the prevalence of HIV/AIDS - the country has an infection rate of about 11.5%, one of the highest in the world (INE, 2015).
6. Many other problems affects directly the conditions of living of population, such as: environmental degradation, many people (60% of the population) without

access to improved water source, and deteriorating shelter conditions in which live the majority of the population.

Second, to attain the recommendations of UNESCO made for Mozambican secondary school after a critical analysis of the curriculum and programs used in this level:

1. Revise the structure of the programs to make them more flexible in the organization of knowledge.
2. Promote a multi-sector approach to develop abilities and competencies needed for life.
3. Promote the development of values and competencies necessary for life (life skills).

Third, to attain the goals of Southern African Development Community (SADC),under the protocol signed in 1997 for regional integration, with particular emphasis on:

1. Change the curriculum to a more integrated approach, instead of subject-based;
2. Reduce the duration of undergraduate courses from 5 to 4 years;
3. Increase the time of permanence of primary school pupils: Mozambican pupils' spend 780 hours per year, while in the SADC region the average time spend at school is between 925 and 1000 hours.
4. Introduce the credit transfer under Bologna system, adapted to the region.

In fact, Mozambique as former Portuguese colony and Portuguese speaking country in the region, adopted a socialist system after independence. Therefore, in the curriculum there are features of socialist's philosophy and principles of social organization with direct impact on the way of teaching and learning. Because of that, the country has a curriculum structured and with some features quite different from other 14 SADC countries (except Angola, because of the similarities in their history).

Fourth, the country designed a long term blue-print development plan call "agenda 20-25". This plan, outlines key issues that any government in charge should be inspired on to design its governing plan. By identifying poverty as the cause of the majority of the problems, in this long term plan the main goal underlying all the actions is ***Poverty eradication.*** From this, a variety of strategies are defined for different sectors, some of them are based on the recommendations of the Millennium Development Goals (MDG) for education, environment, health and building up infrastructures. Although it is a long term plan, it is updated every 2 years by a national panel of experts with assistance of foreign international agencies.

The government acknowledges that "only a population well trained and competent can effective and fully participate in society" (Government Five Year Plan, 2005 - 2009; p.58). This quote is used by curriculum developers of secondary schools to design the curriculum for this level, to make it more integrated (not subject-centered) and towards the development of competencies and abilities for life (not theoretical).

It is in the country with the features presented above where the education takes place. It is important to note that, despite being bellow the average of the region, an encouraging sign is that the country in the past 20 years has been improving in different socio-economic aspects.

2.3. The Educational System

Since the independence in 1975, the country experienced three different reforms to its educational systems:

First, from 1975 to 1977, structurally it was an heritage from the colonial system, since there was no national expertise to design a national educational system.

Second, 1977 it replaced the previous educational system with a new one inspired by a socialist model, defined then as political orientation of the country. Under the new political orientation "***to form a new man"***, the curriculum was subject-centered, and more theoretical aiming to form citizens to act like scientists.

The third and last educational system was implemented in 1983 (law 4/1983). Since this law was introduced in a mono-party system, it was revised in 1992 (law 6/1992), to encompass some aspects of the multiparty constitution introduced in 1990. This system of education is currently in use and was revised in 1992 - has established the following structure, in table below:

Level	Cycles/Grades and Duration	Minimum Entrance Age
Primary	*First cycle*: grade 1 to 5 - 5 years	6 years
	Second cycle: grades 6 and 7 - 2 years	11 years
Secondary	*First cycle*: grade 8 to 10 - 3 years	13 years
	Second cycle: grades 11 and 12 - 2 years	16 years
Tertiary*	*Graduation*: 4 years	17 years and above
	Post-graduation - Masters: 1 to 2 years	Not specified
	Post-graduation - PhD: 3 to 4 Years	Not specified

Table 1: Structure of Mozambican education system. (source: Adapted from law 4/83 and law 6/92). *Ministry of Education - Strategic Plan for Higher Education (2012-2020)

Many things have been happening in Mozambican education sector, and as a result of that some improvements are noticeable. The current educational system is more in line with other SADC countries and thus according to the international standards. Despite that, some crucial problems are of concern, especially in primary and secondary school, namely (MINED, 2007):

- lack of initial training of teachers (about 40% do not have initial training);
- lack of basic didactic materials: learner's book, teacher's book; libraries and lack of laboratories in the majority of schools and they exist they are ill equipped or transformed into classrooms.

Furthermore, to add to these problems, according to the assessment made by the Ministry of Science and Technology in 2007 about the curriculum of secondary schools its is pointed out that:

> *"The curriculum is highly academic and theoretical, do not take into account practical abilities that can be used to allow easy integration of the graduate into the labor market"* (MINED, 2008; p.5).

These problems that are nationwide and more severe in rural areas, can hinder or handicap any effort to change the state of affairs in the sector.

2.4. Patterns of Secondary School Curriculum

In Mozambique, according to the Ministry of education demand to be a secondary school science teacher, both junior or senior, a person needs to have a university graduation degree. The role the teacher is going to take is intrinsically related to the structure of the system (disciplines that encompass secondary school) and the syllabus of each discipline.

An overview about the Science curriculum at secondary school shows that it is centered on disciplines, divided in three areas:

1) language and social sciences;

2) mathematics and natural sciences, and;

3) practical activities and technology.

The curricular plan for secondary school outlines explicitly what is expected in the area of mathematics and natural science with regard to the STS approach proposed in this study (MINED, 2007; p.43):

> *"In this area will be developed competencies that will allow the learner to understand basic concepts of science, develop abilities, strategies, and habits of scientific research and communicate it as well as how to relate science with technology, society and environment."*

In Junior secondary school there are 11 disciplines in the three (3) areas above presented, seven (7) of them in the areas of arts/language and social sciences. The area of mathematics and natural science comprises the following disciplines: Biology, Chemistry, Physics, and Mathematics - these are the compulsory, and should be taken up by all students matriculated until grade 10. The same disciplines are compulsory in the senior secondary school for those who want to follow science or science related courses.

From the structure of secondary school curriculum it can be learned that, to take a science or science related course at tertiary level, a person usually had at least five (5) years dealing with science content of biology, chemistry, physics and mathematics. In these disciplines, they learn concepts (theories, laws and principles) as well as experiments and other practical work. A critical analysis of the syllabus and the way these disciplines are taught reveals that they contain mainly facts and principles and very little about the nature of scientific knowledge. These findings are very similar to the descriptions of the Nigerian science curriculum in 80s (Jejede & Bello, 1988), and can be speculated that the situation is pretty much the same in many African countries.

Looking at the history of education of Mozambique it can be inferred that the curriculum of the country for science area is based or inspired on western model

(Ogunniyi, 1988), first from the former colonizer (Portugal), and after independence adopted from the socialist bloc, specially former USSR and DDR.

A nationwide study conducted in 1997 by INDE - *Instituto Nacional de Desenvolvimento da Educação* (National Institute for Education Development), an institution affiliated to the Ministry of Education, identified (among other issues of curriculum and syllabus of different Grades of primary and secondary schools) five main characteristics of the Mozambican curriculum (MINED, 1997):

1. **Centralized model:** All decisions about the curriculum and its implementation are defined centrally by the Ministry of Education. Whatever is decided and prescribed must be implemented by all schools irrespective of their conditions.

The centralized model of the curriculum goes to the extent of giving specific instructions about teaching strategies and methods to employ in a unit of contents and sometimes in a single lesson (practical work lessons, for example).

The main disadvantage of this model is that it does not take into consideration local factors or the context from which the learner comes. Thus, learning is abstract and not relevant to the learner, because he or she cannot relate to what was learned at school to his or her everyday life.

2. **Annual Grades:** The subject matter and learning outcomes are organized into a system of annual Grades. During the academic year all learners must attain the expected instructional and educational outcomes.

The main disadvantage of this model is that learners can be punished for some aspects beyond their control and beyond the control of the teacher (by a fail).

3. **Academic levels:** Both primary and secondary levels have two cycles, and an exam must be passed to complete each cycle and to be admitted into the upper cycle or a level.

The main disadvantage of this model is that levels and cycles are constructs of the curriculum developers with little or no meaning to learnersôdevelopmental process or to someone outside the system.

4. **Centralized in disciplines:** The subject matter and the syllabi are based on disciplines, most of them separated. Important attention is given to the selection, structure and sequence of the contents of each discipline, which in turn determines the strategies and experiences of the learning process.

The main disadvantage of this model is that learners see each discipline as a closed body of knowledge not related to others, and they struggle to use different disciplines in an integrated form to analyze or interpret a practical situation faced in day-to-day life.

5. Monolingual medium of instruction: Mozambique has about 17 local Bantu linguistic groups. Despite that, the only medium of instruction is Portuguese, which is considered the language of union of all Mozambicans.

In a country where more than 68% of the population live in rural areas with one or more Bantu languages as their first or second language, the use of Portuguese as medium of instruction in earlier Grades can affect their school progression to higher Grades.

Recognizing that these features of curriculum were inadequate to meet the needs and demands of national, regional and international context in 1998 was launched by the Ministry of Education the Strategic Plan 1999 - 2003 (MINED, 1997), to facilitate the regional and international integration with the key purpose to *"Fight the Exclusion and Renovate the School."*

After seven (7) years of implementation of the strategy, in 2007 new curriculum was launched, advocating new and modern approaches and methods of teaching and learning - largely used throughout the world - as stated in the guiding principles for secondary education, such as (MINED, 2007; p.15) :

1. Inclusive education;

2. Promote active citizenship;

3. Teaching centered on the learner;

4. Teaching oriented to the development of competencies and abilities for life.

Although it is not explicitly stated that the learning theories advocated are based on constructivism, it can be inferred from the approaches and methods of teaching and learning suggested that they can only be based on this modern theory. The problem is, are teachers aware of this new theory and its implications for teaching? Most of the teachers, even those with initial pre-service recommended de training, considered the best qualified to teach at secondary school level, were trained using other learning theories, completely different from the constructivist theories.

From the exposed above it can be inferred that in Mozambican secondary school curriculum there is a room to implement new and modern approaches of teaching such as the STS approach proposed in this research.

2.5. University Curriculum

Mozambique faces many challenges to meet the regional standards. One of them is to increase the access of students to higher education institutions - according to the assessment made the country has 0.4% of the total students population at all levels and the regional average is 0.7%, and UNESCO recommendation is at least 1%, according to the *Plano Estratégico do Ensino Superior 2012-2020* (2009).

The ideal level to be a secondary school teacher a person must have a university degree Bachelor with Honours (licenciature) - an undergraduate four year course. In Mozambique several institutions give initial training for secondary school teachers, private as well as public.

The biggest teacher training institution for secondary school in Mozambique is the Pedagogical University (in Portuguese Universidade Pedagógica - UP). This institution was created in 1985 by the government with sole mission to train teachers. During more than 15 years, until 2000, it was the only institution in the country training teachers for secondary schools. All the courses offered at university until 2004 were only for teacher training and education technicians. This pattern changed in 2005 when the university introduced other courses not related to teaching or education.

Since it was established in 1985, during its history the UP underwent three different periods of curriculum change: 1996, 2004 and 2010. The last curriculum change is the one that still being implemented. These changes were motivated from external factors - international and regional integration " *a need to promote the mobility of students within the region as referred in protocol 7 of SADC for education sector."* (Bases e Directrizes, 2008, p.7) and internal factors - to adapt to new reality of the educational context of the country, according to the blue-print document that guided the whole process - *Bases e Directrizes* (BD) (2008).

The main change of the current curriculum from the previous one is that: it has an integrated approach; it advocates the use of modern theories of teaching and learning, and gives a new structure to the courses based on a more integrated approach. The new structure of the courses recommends three (3) components or areas:

- 65% to subject content,
- 25% to psycho-pedagogic and didactics, and

- 10% to a general training.

The change is accompanied with the advocate of use of modern theories as clearly stated in the Bases and Directrizes (2008, p.17):

> "*...to adopt a flexible curriculum that respect a diversity, local knowledge, incorporate new learning technologies throughout the life, learner-centered, using constructivist approach focused on the development of competencies."*

At the Pedagogical University in Mozambique, where this study is carried out, at undergraduate courses, do not exist STS courses or any other forms of teaching using this approach. Thus this approach of teaching is not suggested to be taught as an independent discipline or infused in any subject. Meanwhile, in Post-graduate courses for science (Mathematic, Physic, Chemistry and Biology), STS courses is offered since 2008 as an optional discipline, thanks to the international cooperation between the Pedagogical University and Heidelberg University of Education.

Despite that, taking into account that the STS approach advocates the interdisciplinarity, transdisciplinarity and development of competencies for active citizenship, the same principles are suggested by the Bases e Directrizes (2008). Therefore, within the curricula of different courses offered at the Pedagogical University there is an open space to implement this approach in Mozambican context.

Thus, the STS approach of teaching and learning advocated in this study and proposed to be part of curricula of different courses at the Pedagogical University is grounded in blue print document available in the institution.

2.6. Summary about the Context of the Study

This chapter was designed to give some socio-political and socio-economic characteristics of Mozambique to highlight the particularities of the country. From the description presented above, taken together, these results suggest the research took place in a country with very specific features, of which it is important to stress the following aspects:

1. Mozambique has more than 42 years of independence from colonial regime (since 1975), of which 16 were spent under a civil war. Therefore, despite having a political stability with an all democratic system and institutions

working, the social tissue and the economy of the country is still recovering from the effects of the war.

2. Most socio-economic indicators of the country are below the average of the region (most of them the lowest of the world). Thus, the country is struggling to meet the demands of regional integration, and with it trying to achieve the Millenniums Development Goals by 2015, in key sectors such as education, health, environment and infrastructure.
3. There is a legal basis to introduce new approaches and methods of teaching and learning based on the Government policy, the Ministry of Education (MINED) blue-print documents and the curricular plan for secondary school.
4. The Educational System of Mozambique follows the international trend when it comes to structure and pedagogic guiding principles. Despite that, the secondary school curriculum is highly theoretical, based on disciplines with little application of science and technology.
5. Schools ranging from primary to secondary level face problems of lack of teachers with initial training and lack or poor resources such as libraries, laboratories, teachers' manual and learners' book.
6. At Pedagogical University of Mozambique STS courses are not taught at the undergraduate courses, but STS is an optional discipline in Master's course of Natural Sciences, physics, chemistry, biology and mathematics.

Chapter III: THEORETICAL BACKGROUND

The previous chapter presented the previous chapter, aiming at presenting the context in which the study was conducted.

This chapter moves further by giving a literature background of most of claims made in this research about proposed learning theory, STS approach and practical work in science.

This chapter presents the constructivist theory of learning as the proposed learning theory, discusses in detail the STS both as movement and as an approach of teaching and learning science. The final two issues treated in this chapter are about detailed discussion about practical work the means by which the STS approach is proposed and about conceptual change.

3.1. About the Learning Theory

This thesis proposes the introduction of a new approach of teaching and learning science in Mozambican context. The STS approach itself is based on modern theories of learning (constructivism), opposed to the context in which the proposed method is intended to be applied (based on traditional methods of teaching and learning).

Constructivism is a term used in different fields and within the field with many different meanings. This study is concerned with the use of the term constructivism in science education. Even in this field the term is understood in various ways: as philosophy, as a paradigm, as a program or as a learning theory (Taber, 2011).

Since it is beyond the scope of this study to discuss the differences and communalities of each of these stance, it will consider constructivism as a learning theory, that shade light to an instructional design with direct implications on teachers' and students' activities.

Many authors have researched about constructivism as a learning theory giving a perspective on how learning occurs and its influence on instructional design: Bodner, 1986; Glasersfeld, 1989; Novak, 1993; Phillips, 2000, and Sjoberg, 2010, just to mention few. It is the contention of this study to propose the use of constructivism as a learning theory underpinning all methodological approaches suggested as opposed to other two learning theories: behaviorism and cognitivism.

According to Phillips (2000) the two most popular types of constructivism as learning theory are: (1) Jean Piaget's individual/personal constructivism, and (2) Lev Vygotsky's social constructivism. The author tries to differentiate the two types (Phillips, 2000; p.2).

> *"é .while Vygotsky believes that Piagetôs emphasis focuses too much on internal processes of individuals. Vygotsky considers cognitive development primarily as a function of external factors such as cultural, historical, and social interaction rather than of individual construction."*

For the purpose of this study, and according to the instructional design proposed, both types of constructivism will be used. The personal constructivism will be used to promote cognitive conflict and trigger the process of conceptual change, and social constructivism mainly because it is based on the assumption that meaning and knowledge about the world is developed jointly by individuals.

Thus, the learning theory underpinning the whole study is constructivism, in particular social constructivism. The key ideas of this theory that will guide the implementation of the STS approach are summarized by Sjoberg (2009, p.3), citing Taber (2006):

1. Knowledge is actively constructed by the learner, not passively received from the outside. Learning is something done by the learner, not something that is imposed on the learner.

2. Learners come to the learning situation (in science etc.) with existing ideas about many phenomena. Some of these ideas are ad hoc and unstable; others are more deeply rooted and well developed.

3. Learner has their own individual ideas about the world, but there are also many similarities and common patterns in their ideas. Some of these ideas are socially and culturally accepted and shared, and they are often part of the language, supported by metaphors etc. They also often function well as tools to understand many phenomena.

4. These ideas are often at odds with accepted scientific ideas, and some of them may be persistent and hard to change.

5. Knowledge is represented in the brain as conceptual structures, and it is possible to model and describe these in some detail.
6. Teaching has to take the learner's existing ideas seriously if they want to change or challenge these.
7. Although knowledge in one sense is personal and individual, the learners construct their knowledge through their interaction with the physical world, collaboratively in social settings and in a cultural and linguistic environment.

These ideas clearly show constructivist's view of teaching and learning as well as how should be the instructional design. This study adopted and implemented them to design the intervention process that consisted applying the STS approach of teaching and learning, and students engaged on inquiry type of practical work.

3.2. STS as Movement and Approach of Teaching

In a broader sense the term Science, Technology, and Society, or Science-Technology-Society (STS) can be considered as an issue, and as such: "An STS issue is a scientific and/or technological problem about which there are different beliefs and values." (Hungerford, et al., 1990. p.33). In the context of this study, a belief is considered as an idea which a person or group holds to be true, and a value is the worth a person or group places on something.

Referring to STS as a movement, Solomon and Aikenhead (1997) and Pedretti (1997) highlighted its long story in science education and covering a wide range of theories about the intersection between science, technology and society. They praise the work of Peter Fensham, an Australian science educator who paves the way for the inception and consolidation of STS as new trend in Science Education.

In an attempt to justify why using STS as a perspective and approach in an educational system Kumar & Chubin (2000; p.3) identified three broad goals:

1. making science and technology literacy available for all;
2. preparing the non-college-bound student to compete successfully in a science-and technology- oriented work place, and
3. Equipping the future citizenry with the tools and information necessary for making informed personal and policy decisions concerning the role of science and technology in global society.

From the three goals above presented it can be inferred an educational system of any country that strives to improve science education the use of STS is a must

In different parts of the world where the STS approach is integrated into the science curriculum the main objective is to improve scientific literacy ((Kumar & Chubin, 2000). According to Osborne (2000) & Hudson (2003), scientific literacy can be perceived in four different ways:

1. **Cultural**: Developing the capacity to read about and understand issues pertaining to science and technology in the media.
2. **Utilitarian**: Having the knowledge, skills and attitudes that are essential for a career as scientist, engineer or technician.
3. **Democratic**: Broadening knowledge and understanding of science to include the interface between science, technology and society.
4. **Economic**: Formulating knowledge and skills that are essential to the economic growth and effective competition within the global market place.

However, many science teachers may face practical difficulties to teach STS either as an independent subject or as part of science due to its cross boundaries nature - it has to integrate in functional way knowledge of different fields, posing challenges and opportunities as pointed out by Hughes (2000) and Pedretti & Forbes, (2000). Nevertheless, a key goal of an STS approach is to help students realize the significance of scientific developments in their daily lives and foster a voice of active citizenship (Pedretti & Forbes, 2000).

3.2.1. Historic Perspective about STS

The Relationship between science, technology and society historically was first considered as a social movement and after that as a research paradigm or an approach of teaching within the field of science education.
The Science, Technology and Society (STS) movement emerged in second half of the twentieth century almost simultaneously in Europe and in North America. (Garcia *et al.,* 1996; Cutcliffe, 2001).

According to these authors, throughout its appearance and inception in society the motivation and focus of the STS movement emerged was different in the two geographical regions - Europe and America.

The table below summarize the main focus and features to show the differences between the two traditions:

Features	European Tradition	American Tradition
Origins	***Academic:*** institutionalized by academic programs, constituted by scientists, engineers, sociologists and humanists.	***Social:*** reaction to social movement based on human right activists, pacifists groups, consumer associations among others.
Goal	To investigate the influence of society on the scientific and technological development.	Worried about social and environmental consequences of technological products.
Focus	Focus on science as process rather than product.	Focus on technology seen as product.

Table 2: Different traditions about STS

According to Strieder (2012), in Latin America the first reflections about STS emerged almost several years later and culminated with the launch of the Latin American thought about science, technology and society (in Spanish is PLACTS = El Pensamiento Latino Américano em Ciencia, Tecnologia y Sociedad).

It would be interesting to have STS reflections in other parts of the world with specific cultural background and social context. Unfortunately, from the research made there is no reference of the same movement in Africa or other geographical region to show how widespread is the STS movement.

Nevertheless, despite these differences in the focus and the intentions of the STS movement, currently they are overcome. Currently, irrespective of the place where STS approaches are implemented they have common goals and features, enabling to apply them according to the context of the country and educational purposes defined.

It is important to note that from its very beginning the STS movement was always inspired by social reflections about the influence of science and technology on the society. This mean that despite it being an academic field in science education, STS approach is by nature social bounded and therefore should always be context-based. There are two different opinions about the appearance of the term STS. The first is that it was first endorsed by Gallagher in 1971 (Mbajourg & Ali, 2003). The second is idea is belied that the designation STS was formally endorsed in 1982 after the IOSTE (international organization for Science, Technology and Education) conference, attended by scientists from Australia, Canada, Holland, Italy and United Kingdom (Strieder, 2012).

Prior to the IOSTE conference, it is believed that the book published by John Ziman in 1980 entitled: "Teaching and learning about science and society" in which STS (Science-Technology-Society) was constantly mentioned, contributed to the establishment of this word in science education, to refer to relationship between science, technology and society.

In this research special focus will be placed to STS approach as research paradigm with science education or as a teaching approach. Taking this into account, this study will not look at the debate about whether STS is a paradigm or an instructional design to teaching, but rather look at the consensus agreed upon in scientific community about the goals and purposes of STS. Te next sub-section presents the different names or labels attributed to it.

3.2. 2. Different Labels of STS

Since it emerged in 1960s in science education, STS approach of teaching and learning have been implemented throughout the world with different programs and courses at schools, colleges and university.

Although there is consensus about goals and features of what is understood to be STS approach as a paradigm in science education there are discrepancies about the use of the term. In a quest to find different labels of STS and the proponents, Aikenhead (2005, p.384) compiled eight different labels:

Designation		Proponents
1.	science-technology-citizenship	(Kolstø, 2001a; Solomon & Thomas, 1999),
2.	nature-technology-society	(Andersson, 2000),
3.	science for public understanding	(Eijkelhof & Kapteijn, 2000; Osborne et al., 2003),
4.	citizen science	(Cross *et al.*, 2000; Irwin, 1995; Jenkins, 1999)
5.	functional scientific literacy	(Ryder, 2001)
6.	public awareness of science	(Solomon, 2003)
7.	science-technology-society-environment	on (Dori & Tal, 2000; Hart, 1989),
8.	cross-cultural" school science	Aikenhead, 2000; Cajete, 1999).
9.	Science, technology, environment in modern society (STEMS).	(Tal *et al.*, 2001)

Table 3: Different labels for STS**.**

Under each of these labels different programs and courses are designed and implement in different countries. Despite the differences in labels they share 3 common goals (Aikenhead, 2005, p.384):

- science for all;
- achieve scientific literacy, and
- improve the participation of marginalized students in school science.

Without neglecting other two goals, this research is more concerned with the achieving scientific literacy, because of the main purpose of the research (to propose the introduction of an STS approach in Mozambique), the target population studied (university students), and the context in which the study was carried out (traditional methods of teaching and canonical science curriculum).

From the labels presented it can be inferred that each tries to bring the goals of an STS approach or emphasizing a social problem to be addressed (environment, science for all citizens or active citizens in decision-making).

3.2.3. Different Definitions of STS

In the previous section it was described that different countries use different labels for STS and under the chosen label several programs and courses are designed and implemented to achieve common goals.

There is no consensus about the definition of STS or any other name given to this movement and approach. Mansour (2009) compiled different definitions for STS, presented in the table 4 below:

Proponents	Definition
Nasser Mansour (2009)	Science, Technology and Society STS is an interdisciplinary field of study that seeks to explore and understand the many ways that modern science and technology shape modern culture, values, and institutions on the one hand, and on the other how modern values shape science and technology.
John Ziman (1980)	identified STS as a kind of curriculum approach designed to make traditional concepts and processes found in typical science and social studies programs more appropriate and relevant to the lives of students.
Robert Yager (1990),	STS may be defined as an integrated approach to science teaching,
Wraga and Hlebowitsh (1991)	Have defined STS as a topical curriculum that addresses a broad range of environmental, industrial, technological, social and political problems.
Heath (1992)	STS can be referred to as an instructional approach that incorporates appropriate STS knowledge, skills, attitudes, and values.
Honesties et al. (1988)	define STS as teaching science content in the authentic context of its technological and social milieu,
National Science Teacher Association (NSTA) in USA.	"Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions about current problems and taking personal actions as a result of these decisions. STS means focusing upon current issues and attempts at their resolution as the best way of preparing people for current and future citizenship roles"

Table 4: Different definitions of STS

The common feature that can be inferred from all seven definitions is that STS is viewed as a paradigm in educational context. Nevertheless, it is possible to devise two broad categories. First, explicitly states STS as a research paradigm and the definition emphasizes the nature of STS as curricular approach (interdisciplinary, integrated, instructional, and topical curriculum). Second, it emphasizes the ends of an STS approach, based on the goals of any STS course or program.

This study, by taking into account the aims and research questions, is more focused on STS as an approach, and will adopt the definition of STS given by Aikenhead (1994, p.5):

> *"STS approaches are those that emphasize links between science, technology and society by means of emphasizing one or more of the following: a technological artifact, process or expertise; the interactions between technology and society; a social issue related to science or technology; social science content that sheds light on societal issue related to science and technology; a philosophical, historical, or social issue within the scientific or technological community. "*

This definition shows not only the broader view about the approach, but also the explicitly presents examples of contents and type of relationship between the three words in the acronym STS.

3.2.4. STS in Science Courses

The main purpose of this thesis is to propose the introduction of the STS approach of teaching in Mozambican educational system, starting from university in a teacher training institution.

In order to understand how it is implemented in science courses was necessary to research about problems and claims related to implementation of this approach in science courses.

Clearly, the main reasons for proposing STS approach of teaching and learning in Mozambique is because twofold: first, acknowledging that the current science curriculum is based on canonic science (Aikenhead, 2005) and the organization and practices are based on traditional methods. Second, there is political and educational space and willingness to implement modern approaches of teaching and learning, based on modern learning theories, such as constructivism.

In the table 5 below, Yager et al., (2008), compiled the main features of traditional methods of teaching and learning, compared with the STS approach of teaching and learning.

The table below compares the differences between traditional methods of teaching with STS approach of teaching:

Traditional Methods of Teaching	STS Approach
1. Survey of major concept found in standard textbooks	**1.** Identification of problems with local/personal interest/impact
2. Use of labs and activities suggested in textbooks and accompanying lab manuals.	**2.** Use of local resources (human and material) to locate information and resolve problems/issue.
3. Students passively construct information provided by teacher and textbook.	**3.** Students are actively involved in seeking information to use
4. Learning is contained in a classroom for series of period over the school year.	**4.** Teaching going behind the classroom that was provided as the education structure.
5. Focuses on information proclaimed important for student to master.	**5.** Focuses upon personal impact, making use of student creativity.
6. Views science content as the information included and explained in textbooks and teacher lectures.	**6.** Views science content not as something that merely exists for student to mastery simply because it is recorded in print.
7. Pays no attention to career awareness other than occasional reference to a scientist (most of them are dead) and his/her discoveries.	**7.** Focuses on career awareness, especially careers that are related to science and technology that students might pursue, emphasizing careers in areas other than medicine, engineering, and scientific research.
8. Students concentrate on problems provided by teachers and textbooks,	**8.** Students become aware of their citizenship roles as they attempt to resolve issues/problems that they identified.
9. Science learning occurs only in the classroom as a part of the school curriculum.	**9.** Students see the role of science in a given institution and in a specific community.
10. Science class focuses on what has previously known.	**10.** Science class focuses on what the future might be like
11. There is little concern for the use of information beyond the classroom and performance on tests.	**11.** Students are encouraged to enjoy and to experience science.

Table 5: Comparison between traditional methods with STS approach. (Source: Yager et al, 2008).

From the information presented in the table above it can be devised the four categories:

- *Student-teacher relationship*: student passively or actively engaged in the learning process, with the teacher acting as the deliver or the facilitator.

- *Classroom organization and management*: prescribed task with students to work sitting one behind another, compared with exploring problems from student's social context, and students sitting in groups and working in pairs or group.
- *Approach to the subject matter*: information confined to textbooks compared to the use of different sources of information to deal with the subject matter, respecting student's prior experience and problems from the context where he/she comes from.
- *Use of what is learnt*: use of what is learnt in restricted context (not relevant for student's life), compared to expanded context to use what was learnt (meaningful learning).

All these issues matter for the purpose of this study, thus they will be taken into account when implementing the approach in Mozambican context. As a teacher training institution, special emphasis will be given to pre-service and in-service teacher training with new roles assigned for the teacher based on STS approach.

Focusing on the teacher, (Yager et al., 2008, p.188) suggested five pre-conditions to implement successfully the STS approach of teaching:

1. Prior experience of teachers with STS;
2. The level of ñinquiryòthey are willing and able to try;
3. Their attitudes;
4. The extend of cooperation and communication with their colleagues and
5. The level to which their instruction focuses on student construction of concepts.

From the pre-conditions above presented it can be sensed that implementing STS approach is a huge challenge for the teach and he/she has to change beliefs, motivations and attitudes. This is an enormous and complex task, considering the current practices in teacher training and the context of the education at primary and secondary school, characterized by: overloaded time table, crowded classrooms and lack or low motivation due to low salaries.

In addition to the complexity of the role of the teacher, supposing that they are overcome, there are imprecision derived from STS courses themselves (Yager et al., 2008):

1. *Function* ï what are the goals for teaching science through STS?
2. *Content* ï what should be taught?
3. *Structure* ï how should the science and STS content be integrated?
4. Sequence ï How can we design STS instruction?

These dilemmas are faced by a teacher even when he/she is qualified for the job, and even when there is a clear STS course or syllabus. One of the ways to minimize the negative impact derived from the imprecision above presented is important to have deep knowledge about the features of an STS approach of teaching and learning.

3.2.5. Features of STS Approach

As a research paradigm and research line in science education Zoller (1990), highlighted four major goals:

1. Critical thinking and high-level thinking;
2. Higher-order cognitive skills;
3. Problem solving skills;
4. Decision-making capacity

Any STS course or program designed should take into account these goals and they should guide the definition of the content and the role of teachers and students. Based on these goals it is possible to devise key features of an STS course or program when it is implemented.

The National Science Teacher Association (NSTA) from the United States of America identified eleven (11) main features of an STS approach of teaching:

1. Student identification of problems with local interest or impact;
2. The use of local resources (human and material) to locate information which can be used in problem resolution;
3. The active involvement of students in seeking information that can be applied to solve real-life problems;
4. The extension of learning beyond the class period, the classroom, the school;
5. A focus on the impact of the science and technology on individual students;
6. A view that science content is more than concepts which exist for students to master on tests;
7. An emphasis upon process skill which students can use in their own problem resolution;
8. An emphasis upon career awareness ï especially careers related to science and technology;

9. Opportunities for students to experience citizenship roles as they attempt to resolve societal issues they have identified;
10. Identification of ways that science and technology are likely to impact the future, and
11. Some autonomy in the learning process as individual issues are identified and used as the basis for science study.

These features are very clear, but not always easy to attain, even for the most committed teachers, in a well equipped schools, and with highly motivated students. Nevertheless, there are positive examples of successful implementation of STS courses throughout the world.

3.2.6. Claims about STS Approach

Despite some skepticism about the implementation of STS approach, Aikenhead (2005) gathered research-based evidence conducted by (Aikenhead, 2003; Manassero-Mas *et al.*, 2001; Manassero-Mas & Vázquez-Alonso, 1998; Vázquez - Alonso & Manassero-Mas, 1999) and made six (6) main claims about positive impact derived from the implementation of STS approach:

1. Students in STS science classes (compared with traditional classes) can significantly improve their understanding of social issues both external and internal to science, and of the interactions among science, technology, and society; but this achievement depends on what content is emphasized and evaluated by the teacher. The teacher makes the difference.
2. Students in STS science classes (compared with traditional classes) can significantly improve their attitudes towards science, towards science classes, and towards learning, as a result of learning STS content.
3. Students in STS science classes (compared with traditional classes) can make modest but significant gains in thinking skills such as applying canonical science content to everyday events, critical and creative thinking, and decision making, as long as these skills are explicitly practiced and evaluated in the classroom.
4. Students can benefit from studying science from an STS perspective provided that: the STS content is integrated with canonical science content in a purposeful, educationally sound way; appropriate classroom materials are available; and a

teacherø orientation towards school science is in reasonable synchrony with an STS perspective.

5. Some students can enhance their socially responsible actions when taught by certain teachers.

In addition, researchers found that even though STS content made intuitive sense to many students, the students still required guidance from their teacher on how to apply their intuitive knowledge to a particular event.

All the above presented claims are focused on students, but to implement an STS approach other elements play a role. For instance, there are some concerns posed by teachers regarding the implementation of STS approach of teaching. They are as follow (Yager, et al., 2008):

1. Concerns over the dilution of science content;
2. Discomfort with cooperative learning;
3. Difficulty assessing student work;
4. Frustrations regarding varying student ability levels;
5. Traditional conceptions of the role of the teacher, and
6. Unwillingness to deal with issues not part of their own science preparation.

All these are practical issues that have to be addressed when implementing an STS approach in the context of a country. There are also research-based evidence which show problems when implementing an STS approach looking the issue at teacher's perspective, as pointed out by Aikenhead (2005, p.398) :

> *"As with in-service studies, research into pre-service science teachersø orientation to an STS perspective did not find encouraging results. Pre-service teachers have loyalties and self-identities recently established in their university science programs. Researchers who followed these teacher education students into their practice teaching found that little or no STS instruction occurred, in spite of the studentsø grasp of, and commitment to, this content. "*

The underlying assumption in the statement above is that in-service teachers would have more problems to apply an STS approach compared to pre-service teachers. It seems that the results show otherwise, mainly because, according to the author, of the influence of the training they got at the university.

For the context of this study and based on the reasons advanced to implement an STS approach there are four (4) main research-based remarks made by Aikenhead (2005):

1. An STS approach to science education aims to develop a student-centered orientation that animates studentsôcultural self-identities, their future contributions to society as citizens, and their interest in making personal utilitarian meaning of scientific and technological knowledge.
2. Is STS science education credible? The research literature presents us with two clear answers: educationally it is unmistakably credible, but politically it is not. Therefore, all future innovative STS projects will need to incorporate both an educational and political component if innovators are to make a significant difference to what happens in a science classroom.
3. However, a change from a traditional curriculum to an STS science curriculum may require even a broader context than just a school system. Significant change requires a multi-dimensional context of scale that includes diverse stakeholders of social privilege and power, over a long period of time. Successful collaboration requires new partnerships among educators, researchers, and stakeholders, forging new actor-networks in support of STS science education.
4. The largest obstacle to changing the curriculum is change itself. Change is well-known to the scientific community because scientists shift paradigms from time to time, but not without difficulty. I predict that the time is now ripe for science educators to shift from a traditional paradigm to an STS paradigm for school science, in order to ensure educational excellence and relevance for all students.

These statements encompass the rationale and the whole idea that lead to propose the introduction of STS approach in Mozambican educational system.

3.3. Practical Work in Science

One of the best ways of teaching science is by mean of practical work. In fact, teaching science without practical work can be compared to swimming without water. In a survey carried out in England, found that the three most enjoyable aspects of studying the sciences are: "hands-on practical in laboratories, visits and excursions outside schools". (Dillon, 2008, p. 10). The same situation can be generalized with some caution to other countries.

Practical work, when well designed and done adequately, is one of the most effective tool or method to develop ñprocess skillò of science. Akinbobola & Afolabi (2010)**;** Lyall (2010); Morgil *et al.* (2007a)**;** Morgil *et al.* (2007b); and Morgil & Temel, (2007).

There should be a careful preparation and consider many issues when considering doing practical work as suggested by Akinbobola & Afolabi (2010, p.34):

> *"Practical work is not just putting the apparatus together when seen, but it needs planning, designing a problem, creating a new approach and procedure and also putting familiar things together in new arrangement. This implies that the knowledge of creativity by candidates in any practical class helps them to manipulate some practical equipment.**ò***

From this statement that by doing practical work students are required not to have only "hands-on" but also "minds-on" (Bradley, 2000) and should link two domains: domain of real objects and observable thinks and domain of idea (Millar, et al., 2002). In addition to that ñFactual knowledge is not sufficient. Understanding science requires complex cognitive abilities of individuals.ò (Teacher Science Partnership, 2011).

Despite some critics about some assumptions made about the role of practical work in science teaching, it is still well acknowledged the important role and benefits of laboratory work on teaching and learning science. To corroborate this view an evaluation of thirty years of experience in Israel concluded that:

> ***ñ** Laboratory activities have long had a distinctive and central role in the science curriculum and science educators have suggested that many benefits accrue from engaging students in science laboratory activities.**ò*** (Hoffstein, 2004, p. 12).

In some critics about the traditional, or expository laboratory work, it is suggested that practical work should be done in such a way that it develops other process skill. Hoffstein (2004) and Hoffstein & Naaman (2007) suggested variables that should be taken into account when designing and performing laboratory work:

1. Learning objectives;
2. The nature of the instructions provided by the teacher and the laboratory guide (printed and/or electronic and/or oral);
3. Materials and equipment available for use in the laboratory investigation;
4. The nature of activities and the student-student and teacher-student interactions during the laboratory work;

5. The students´ and teachers´ perceptions of how students´ performance is to be assessed;
6. Students´ laboratory reports; the preparation, attitudes, knowledge, and behaviors of the teachers.

Taking into account these variables the laboratory work should be designed and carried out based on constructivist instructions. Within this learning theory there is no room for expository laboratory work, but other types of laboratory work: inquiry, discover or problem-based (Macaroglu & Oztuna, 2009).

3.3.1. Purpose of Practical Work in Science

Defining the purposes of practical work is not a task without contradiction, despite some clarity about its relevance for science teaching and learning. If there are many activities that take place in school science classified as practical work (Dillon, 2008), then it can be assumed that for each type of activity will have different purposes.

According to Dillon (2008), while there are many espoused purposes for doing practical work in school science the most frequently stated are:

1. To encourage accurate observation and description;
2. To make phenomenon more real;
3. To arouse and maintain interest, and
4. To promote logical and reasoning methods of thought.

All these purposes are focused on the activities that occur inside classroom when performing practical work. Other way of defining the purposes of practical work would be looking at it as a whole or as a result of leaning process. By doing that, the purposes frequently stated are: to increase students' motivation towards science; to relate school content with daily life; to have a feeling as scientist, to encourage students to pursue science and science related courses at tertiary level, to have awareness about environmental and other social problems.

It is important that all the participants be clear about the importance and role to play when performing practical work in order to achieve the proposed goals.

> *"Despite the benefits of laboratory work, the students rarely focus on their purposes. In other words, student try to see or determine only the expected results from the activities, but they do not invest much mental engagement in*

relating other learning experiences to laboratory work. Laboratory instruction should give students wider range of learning experiences than verifying textbook claims. " (Saribas & Byram, 1998, p.62).

From the statement above it can be inferred that most of the purposes of practical work can only be achieved depending on the type and how students are engaged in the activities performed in the laboratory.

3.3.2. Types of Practical Work

Used properly, the laboratory is especially important in the current era in which *inquiry* has re-emerged as a central style advocated for science teaching and learning (NRC, 1996, p.23).

In science inquiry is essential in practical work. Taking into account the levels of inquiry Cheung (2007) identified four (4) types of practical work:

1. Confirmation inquiry - verifying concepts by following a procedure;
2. Structured inquiry - following a procedure to find an answer;
3. Guided inquiry - teacher provides a question, students design and experiment to find answer;
4. Open inquiry - students ask the question, then find answer.

In most of Mozambique secondary schools or even at university, the practical work performed is mainly confirmation inquiry type at most structured inquiry. In order to achieve the goals of practical work it would be desirable to use guided inquiry or open inquiry types of practical work. Cheung recommends the use of guided inquiry type of practical work.

The type of practical work advocated for this research during the intervention process is open inquiry type, a breakthrough from what the students are used to do, frequently confirmation inquiry type and sometimes structured inquiry type. While the guided inquiry and open inquiry types of practical work are based on constructivist theory, the later is the one that fully fulfill the features of the constructivist method of teaching and learning. Furthermore, the two types of practical work are the ones that contribute most to developing both basic process skill, and integrated process skills (Akinbobola & Afolabi**,** 2010).

while the type of practical work above presented gives students' role in broad terms, Fay et al., (2007) add to it some more details as presented in the table 6 below.

Level of Inquiry	Description
0 Confirmation inquiry	The problem, procedure and methods for achieving solutions are provided to the student. The student performs the experiment and verifies the results with the manual.
1 Structured inquiry	The problem and procedure are provided to the student. The student interprets the data in order to propose viable solutions.
2 Guided inquiry	The problem is provided to the student. The student develops a procedure for investigating the problem, decides what data to gather, and interprets the data in order to propose viable solutions.
3 Open inquiry	A "raw" phenomenon is provided to the student. The student chooses the problems to explore, develops a procedure for investigating the problem, decides what data to gather, and interprets the data in order to propose viable solutions.

Table 6: Scientific inquiry rubric**.**

The Inquiry-type laboratories have the potential to develop students' abilities and skills such as: posing scientifically oriented questions (Krajcik et al., 2001; Hofstein et al., 2005), forming hypotheses, designing and conducting scientific investigations, formulating and revising scientific explanations, and communicating and defending scientific arguments. These features are required to engage students to act as scientists and perceive the way current body of scientific knowledge was formed.
Tobin (1990, p.405) wrote that: ñLaboratory activities appeal as a way of allowing students to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing scienceò. This statement shows not only the importance of laboratory activities but also a need to use constructivist methods when performing them.
The overall objective is to create a learning environment that allows students to interact physically and intellectually with instructional materials through hands on experiences, and through minds-on and inquiry-oriented activities (Tobin, Capie & Bettencourt, 1988).

3.3.3. Integrated Science Process skill

One of the goals of science education is the development of scientific literacy. Practical work, when well designed, and implemented is one of the most effective means to achieve scientific literacy, understood as:

"Use the habits of mind and knowledge of science, mathematics, and

technology they [students] have acquired to think about and makes sense of many of the ideas, claims, and events that they encounter in everyday life." (AAAS, 1993, p.322).

It is clear from the definition that it the learning process goes beyond school time, beyond the school and demands active and conscious participation of the students in social life. By its nature, practical work is the one that can better contribute to that.

The Programme for International Student Assessment (PISA) 2000, defined scientific literacy along with reading and mathematical literary as key elements do assess students´ understanding and skills, along its 29 member countries. According to them, scientific literacy is:

ñ*the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.****ò*** (OECD, 2000; p.25).

To transform this definition into an assessment of scientific literacy, there are three broad dimensions (OECD, 2000).

- Scientific processes or skills;
- Concepts and content and
- Context.

From what is presented above it can be inferred that, all process of teaching or learning science, irrespective of the learning theory used will have to lead to scientific literacy of students.

By doing practical work is expected students to develop science process skills, both basic and integrated. **(**Akinbobola & Afolabi, 2010):

1. ***Basic process skills*** (simpler) **-** provide a foundation for learning integrated (more complex). They are vital for science learning and concept formation at the primary and junior secondary school level and

2. ***Integrated process skills*** **-** appropriate at secondary and tertiary school for the formation of models, experimenting and inferencing.

The table 7 below presents some science process skills that can be developed through practical work . **(**Akinbobola & Afolabi, 2010, p.35):

Basic Science Process Skills	Integrated Science Process Skill
Observing;	Controlling variables;
Measuring;	Hypothesizing;
Classifying;	Defining operationally;
Communicating;	Formulating models;
Predicting;	Designing experiments and
Inferring;	Interpreting data.
Using number;	
Using space/time relationship;	
Questioning;	

Table 7: Science basic and integrated process skills

Both categories of skills in the table 7 above can fully be developed depending on the type of practical work, the higher the level of inquiry more skills are developed. All skills are important, but the development of integrated process skills depend on the mastering of basic process skills. Furthermore:

> **ñ***The basic science skills are useful in science and non-science situation while the integrated process skills are working behavior of the scientists and technologists. Thus, both basic and integrated science process skills are relevant and appropriate for all science subject***é ò (**Akinbobola & Afolabi, 2010, p.36):

For the purpose of this study, and taking into account the intervention design and the outcome expected from it, students the open inquiry type of practical work was assigned, expecting to develop integrated science process skills in order to answer VOSTS items related to nature of science.

An assurance that these science process skill are relevant comes from the content of science selected for inclusion in PISA (Harlen, 2010, p.54):

1. Recognizing scientifically investigable questions;
2. Identifying evidence needed in a scientific investigation;
3. Drawing or evaluating conclusion;
4. Communicating valid conclusions;
5. Demonstrating understanding of science concept.

From these issues it can be easily inferred that they are based on science process skills, most of them can be developed through practical work, designed using inquiry type approach and student centered approach.

3.4. Conceptual Change

One of the core issues to be addressed in this study is to assess students' opinions about STS issues. Most of the issues assessed are based on scientific concepts, nature of science and the influence society in science and technology.

Conceptual change is one of the most researched and influential topics within science education community (Anderson, 2010).

In an attempt to find out the roots, origins and the establishment of conceptual change tradition in science education Anderson (2010, p.7) stated:

> *Conceptual change research emerged when investigators began to link Piaget's method with ideas about the historical development of scientific knowledge, notably those of Kuhn (1970) and Toulmin (1962, 1972). Posner, Strike, Hewson, and Gertzog brought these strands together in a seminal article in 1982, suggesting that individual learners had "conceptual ecologies" like those used by Toulmin to describe scientific disciplines, and that learning in individuals resembled the complex process of theory change in science."*

With this overview about the historic perspective of conceptual change in mind it can be moved to the consideration about the meaning of the term. The term ñConceptual Changeò can be viewed in a broader sense, as views or approaches of prospective teachers about teaching and learning science in general, rather than concepts related to content of a subject or conceptions held by teachers or learners. For the purpose of this thesis conceptual change will be considered as:

> ***ñé*** *not as replacement of an incorrect naïve theory with a correct theory but rather, as an opening up of conceptual space through increased meta-conceptual awareness and epistemological sophistication, creating the possibility of entertaining different perspectives and different points of views.**ò***
> (Duit & Treagust, 2008, p.8).

In fact the study is more concerned with identify the nature of conception students possess in each VOSTS item and categorize the type of conceptions according to categories devised, rather than evaluate in details the nature of choices made and identify reasons for mistakes or correctness of the choices made.

According to Nussbaum & Novick (1982), there are four main teaching strategies for conceptual change:

1. Reveal student preconceptions
2. Discuss and evaluate preconceptions
3. Create conceptual conflict with those preconceptions
4. Encourage and guide conceptual restructuring

These four steps must occur sequentially in order to change an existing idea, concept, belief or way of thinking. Thus, the first and most significant step in teaching for conceptual change is to make students aware of their own ideas about the topic or phenomenon under study (Duit, 1999).

Conceptual change in this study is expected to occur after the intervention in which they students were performing practical work in an open-ended inquiry type. It is expected students to change their opinions, ideas or beliefs about the STS issues assessed on the 13 VOSTS items selected for the study, and administered before (pretest) and after (post-test) 12 weeks intervention.

Chapter IV: RESEARCH METHODOLOGY

After giving a theoretical background in the previous chapter, this chapter gives a literature review about the research methodology used.

This chapter describes and discusses the research approach and methodology used to carry out the study. It describes the research paradigm used, the methods and techniques applied, as well as the instruments used to collect the data.

The chapter starts by presenting the design used in this research, then moves by giving and overview about the research paradigm in which this study can fit it. In the end it presents the procedures and instruments used to gather data and answer the research questions and achieve the aims of the research.

4.1. Research Paradigm

In order to answer the research question and achieve the goals of this study certain procedures were used and all together can be labeled as research methodology. The importance of it in a scientific work has been well stressed by (Rajasekar et al., 2013, p.5):

About the role of research methods it is pointed out:

> *"Particularly, scientific research methods call for explanations based on collected facts, measurements and observations and not on reasoning alone. They accept only those explanations which can be verified by experiments."* (Rajasekar et al. , 2013, p.5).

In fact this chapter is concerned with giving theoretical background about the approach and procedures used to collect data, and the rationale for using some of the instruments selected for data gathering.

Taking into account the problem stated, the aims of the study, and the research questions, combined with the research design devised, it can be inferred that the best way to approach the study is by using mixed-methods paradigm, because it combines both qualitative and quantitative approaches (Rossman & Rallis, 2003; Creswell, 2009; Cohen & Manion, 2011; Denzin & Lincoln, 2011).

Put in a simple way, when a researcher combines elements of qualitative and quantitative approaches is considered using mixed methods approach (Denzin & Lincoln, 2011).

Referring to the cross-information provided by the mixed method approach to answer research questions Creswell (2009, p.137) stated:

"Because a mixed methods study relies on neither quantitative or qualitative research alone, some combination of the two provides the best information for the research questions and hypotheses."

The advantages of combination of both approaches is well elucidate in the statement below:

" é there is more insight to be gained from the combination of both qualitative and quantitative research than either form by itself. Their combined use provides an expanded understanding of research problems. " (Creswell, 2009, p.203).

From this statement it can be inferred that the mixed-methods approach uses the strength of each approach and helps to find best solutions for the phenomenon studied.

Below its described the features of the qualitative and quantitative approaches used in this study.

4.1.1. Quantitative Approach

Qualitative approach rely on numbers to make inferences about the phenomena studied. Two main features determined the quantitative approach in this study: first, the use of survey to set up the baseline, and second the use of quasi-experimental design for the intervention process, with pre and post-test, without a comparison group.

The baseline study is usually considered before implementing a program with the aim to identify benchmarks before the introduction of the proposed intervention (Freudenthal & Narrow, 1993). In this study the baseline study was appropriate because the proposed STS approach is novel to the country and was necessary to have baseline information regarding views and beliefs of Mozambican students about STS issues and then compare with the outcome of the intended intervention process.

A quasi-experimental or semi-experimental is used when a study is not truly or pure experimental design, with pre and post-test and control and experimental group (Cohen & Manion, 2011). in this study a quasi-experimental approach was used because there was pre and post-test, there is an intervention, but there is no control group to compare the impact of the intervention made. The reason for that is the fact that in each year and in each branch the Pedagogical University usually has one class, therefore was difficult to have students with the same characteristics in the same year.

Two main features determined the quantitative approach in this study: first, the use of baseline study, and second the use of quasi-experimental design for the intervention process.

The baseline study is usually considered before implementing a program with the aim to identify benchmarks before the introduction of the proposed intervention (Freudenthal & Narrow, 1993). In this study the baseline study was appropriate because the proposed STS approach is novel to the country and was necessary to have baseline information regarding views and beliefs of Mozambican students about STS issues and then compare with the outcome of the intended intervention process.

4.1.2. Qualitative Approach

There are three main features that determined the qualitative approach in this study: first, the use of case study, second the use of an observation schedule to describe the learning environment, and third the post-intervention interview with some students who participated in the intervention process.

Case studies are considered one of the methods in the qualitative approach. (Denzin & Lincoln, 2011; Cohen *&* Manion*,* 2011). In this study the whole thesis can be considered a case study. According to Njie & Asimiran (2014, p.37):

> *"The case study is a demarcation of a group, area or a situation for the purposes of concentrating intrinsically on it to understand and explain how it is living its case of interest."*

To avoid making the research too broad one of the criteria to binding the case study is time and place (Creswell, 2003).

In this study case study was appropriate, because it focus particularly to verify views and beliefs of students enrolled at the Pedagogical University, one among many other tertiary institutions in Mozambique. The target population in the baseline were all second year students from all branches countrywide. Furthermore, the intervention process was done in two years using two different classes of second year chemistry students.

Participant observation is considered as tool for data collecting in qualitative research and can be defined as "the systematic description of events, behaviors, and artifacts in the social setting chosen for study" (Marshall & Rossman, 1989, p.79). In this research was necessary to use this method of data collection to register interaction student-teacher, student-student and students' attitude during the intervention process. Beside field notes, video recording of students performing some experiments were taken. It is important to note that the intervention and was done in two consecutive years each time lasting 12 weeks. Thus, the insights of what happened would not be fully understood relying only in the pre and post-test.

Interview is a method commonly linked to data collecting in the qualitative approach. "The purpose of the research interview is to explore the views, experiences, beliefs and/or motivations of individuals on specific matters" (Gill, et al., 2008, p.292). This method was used in this study to have students' evaluation of the intervention process they were exposed to during twelve weeks using new approach of learning chemistry and by applying different method of doing practical work.

4.1.3. Mixed Methods Approach

The table below summaries the features employed in this study that makes it a mixed-method approach by using features both qualitative and quantitative approaches.

Features of Quantitative Approach	Features of Qualitative Approach
- Survey: Administration of questionnaire to 832 all second years students of four science and science related courses: agriculture, biology, chemistry and physics;	-The case study of UP as a whole (part of Mozambican university students) and one branch as part of the UP.
- Pretest followed by an intervention made to 59 second year chemistry students and post-test in the end,	- Classroom observation about the learning environment where students were performing practical work.
	- Post-intervention interview to some students who performed practical work.
Combination of both approaches: Triangulation of data yield from quantitative and qualitative approach to make inferences and answer the research questions.	

Table 8: Features of mixed-method approach in this study

One of the key features of this study that makes it a mixed-methods approach is the use data triangulation, understood as use of different forms of collecting data to investigate a phenomenon. (Rossman & Rallis, 2003; Creswell, 2009; Cohen & Manion, 2011; Denzin & Lincoln, 2011). This method was appropriate for this study in other to have a deep insight about the learning environment, prior (pretest), during (participant observation), and after the intervention process (post-test) and post intervention questionnaire.

4.2. Research Design

By research design is understood the approach and procedures used by the researcher to solve problem posed and gather data in order to achieve the aims of the research and answer the research questions.

The following study design was assembled:

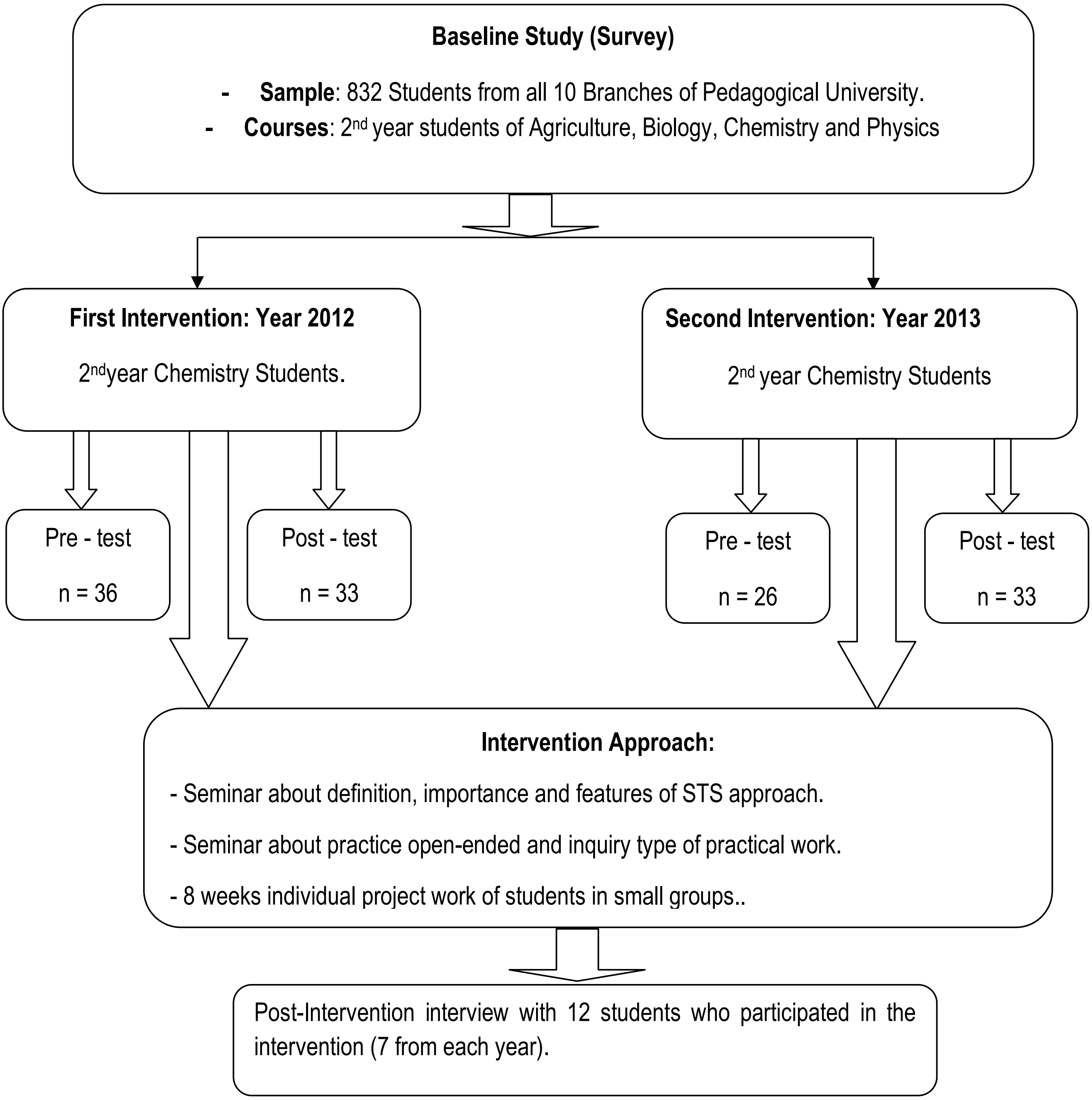

Figure 2: Study design for the thesis.

The number of students who responded in pre and post-test in both years were different: in the first tier (2012) the number reduced from 36 to 33, so the late has be taken into account, and in the second tier (2013), the number increased from 26 to 33, so the former was taken into account. So, the total number of participants considered for the intervention process was 59 (responded both pre and post-test) - 33 from the first year and 26 from the second year.

The key assumption behind this study design was that, since the proposed approach was novel to the country, a baseline situation was necessary to find out students' conceptions regarding STS issues. Then, in lights of the results of the survey assess whether the intervention made contributed to change students' conceptions.

The two years of intervention was made in an iterative way of doing research, because STS is completely new approach of teaching and learning in the country, and it was necessary to do it in order to make valid inferences from the results.

4.3. The Sample Size Used

The sample chosen for this study were students taking up second year from natural science courses (biology, chemistry and physics) and science related course (agriculture) at the Pedagogical University. The sample used was all students available in the target group who agreed to take part in the study, after being requested to do so.

With this countrywide spectrum of students studying at the Pedagogical University it is believed that they are representative of country's students who take up science course throughout junior and senior secondary school. The purpose of the survey was to have a baseline situation about the *status quo* of students' beliefs and views related to STS in Mozambican context. According to Freudenthal & Narrowe (1993, p.10):

> *"**é** ..baseline information is used to identify indicators which can be used to demonstrate that a project-related has been reached and/or that a change has occurred."*

In this study the baseline was necessary to obtain data to compare with the results of the intervention made by using the STS approach of teaching, since there is no record in the history of the country, before and after independence in 1975, of any study carried out about STS, and it is a novel teaching approach proposed to be introduced in the country.

The target population of the survey were second year students from four (4) courses taking up science courses to be teachers of biology, chemistry and physics and agriculture as a science related course. The underlying assumption to select those students is that they had science natural science disciplines: biology, chemistry and physics as separate disciplines for at least five (5) years throughout the junior secondary school (grade 8 to 10), and senior secondary school (grade 11 and 12). Furthermore, at university level, in their first year they have physics and biology at chemistry course, and chemistry at physics and biology course. Therefore, it is assumed that they are familiarized enough with science content to have own views about science and technology to answer the VOSTS item selected for the survey.

Below the map of Mozambique with all the branches of the University:

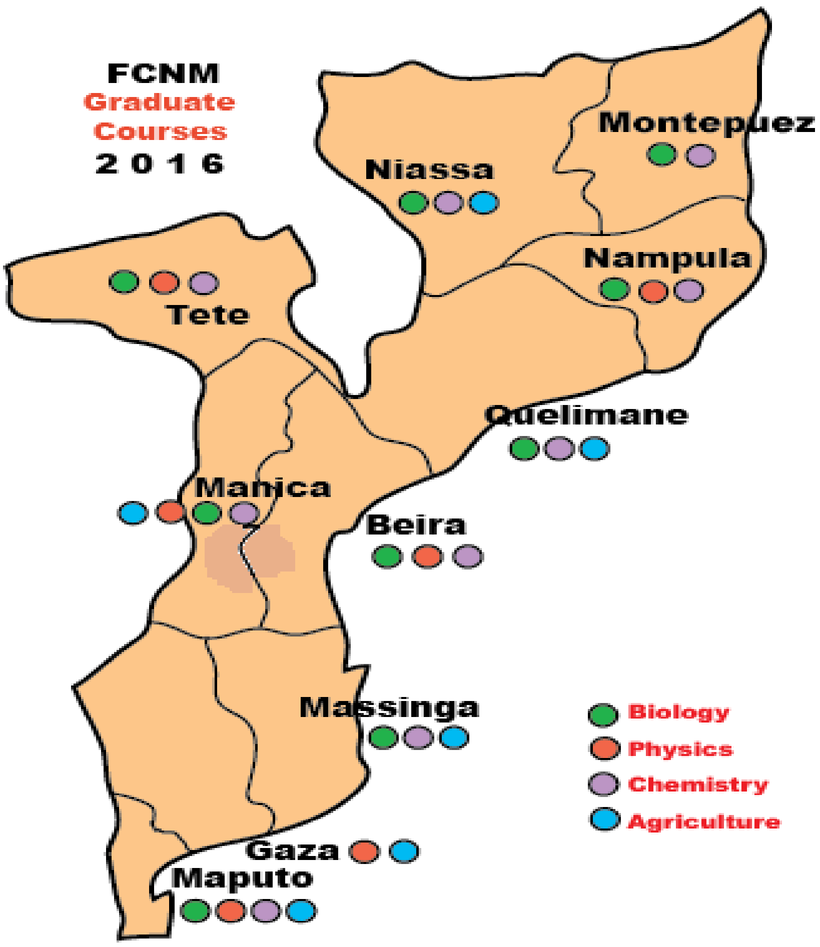

Figure 3: Map of Mozambique with the Location of Branches and Courses Involved in the Study**.**

The table below shows the branches covered in the study, and the number of participants in each course per branch and the overall in each of the four courses.

Branch	***Course***				**Total**
	Biology	***Chemistry***	***Physics***	***Agriculture***	
Maputo	28	28	16	15	*87*
Manica	33	22	26	18	*99*
Massinga	34	34	X	30	*98*
Beira	25	29	25	X	*79*
Nampula	48	*25*	*28*	X	*101*
Niassa	42	39	33	32	*146*
Gaza	X	*X*	26	*23*	*49*
Quelimane	*30*	25	*X*	*27*	*82*
Tete	21	18	11	X	*50*
Montepuez	25	16	X	X	*41*
Total:	***286 (34%)***	***236 (28%)***	***165 (20%)***	***145 (17%***	***832***

Table 9: Participants of the survey per branch and course. **X =** *The Course is not been offered at the branch*

The branches are located in each of the ten (10) provinces of the country. There are some critical differences across the branches due to the socio-economic and cultural conditions of each province, and the age of the branch: the oldest have been working since 1986 (Maputo) and 1990 (Beira Branch), and the youngest one were opened in 2009 (Manica, Montepuez) and Tete (2010). In between were opened Nampula branch (1995); Quelimane (1999); Niassa and Gaza (2005), and Massinga (2007).

The intervention process was made in two consecutive years using two different classes of second year chemistry students from Manica branch of the Pedagogical University.

From the data presented in the table above the following information can be inferred from the target group of 832 participants:

- Biology Course is offered in 9 branches with 286 participants (34%);
- Chemistry course is offered in 9 branches with 236 participants (28%);
- Physics course is offered in 7 branches with 165 participants (20%), and
- Agriculture course is offered in 6 branches with 145 participants (17%).

On the other angle the information presented in the table above can be looked taking branches as reference. From it can be inferred that:

- Three branches offer the four courses: Maputo, Manica and Niassa;

- Five branches offer three courses: Massinga, Beira, Tete, Quelimane and Nampula;
- Two branches offer two courses: Gaza and Montepuez.

Because of these discrepancies of numbers of courses offered in each branch the data analysis of the survey will privilege students' responses per course, rather than per branch.

On the other hand, students' responses per gender will not be used because the number female participants in overall is low (less than 25%), and furthermore, there is missing information in all courses in Niassa branch and in one course (agriculture) in Manica branch. Despite that missing information about gender representation in these two branches, it is possible to devise a common trend: biology and agriculture courses have more women compared to chemistry and physics, the later being the course with less women compared to others. In overall the in all branches and all courses the number of male students is higher than of the female except in biology course in Maputo where the number of female students surpasses the male counterpart.

The table below summarizes the number of participants in the intervention process in the two tiers:

	Second Year Chemistry	
	First Tier 2012	***Second Tier 2013***
Pretest	36	26
Post-test	33	33

Table 10: Sample of students who participated in the intervention.

From the data presented in the table 12 above it can be seen that the number of students who participated in pre and post-test was different in both years. It reduced from 36 to 33 in the year 2012 and increased from 26 to 33 in the year 2013. In order to have the same students who responded to pre and post test, the 3 students who did not answer to the questionnaire in post-test were taken out, likewise the 6 students who responded to post-test but did not answer the pretest were taken out. Therefore, for the purpose of analysis of the whole intervention process the sample size used was 59 students - the number of those who answered both pre and post-test.

4.4. The VOSTS Instrument

According to the study design assembled for this study the key instrument used for data gathering, both in the survey and in the intervention process is designated VOSTS (Views on Science, Technology and Society). The VOSTS instrument is a pool of 114 multiple-choice items designed by Aikenhead, Ryan and Fleming during seven years using secondary school Canadians students (Aikenhead *et al.* , 1992).

The clear definition and purpose of VOSTS instrument is given by Aikenhead & Ryan (1992, p.480):

> *"The VOSTS is designed to assess students' views of STS issues. It consists of 114 multiple choice items addressing a broad range of STS topics with possible responses derived empirically from the domain of the student viewpoint."*

The 114 items are categorized in eight (8) sections , namely: (1) science and technology; (2) influence of society on science/technology; (3) influence of science/technology on society; (4) characteristics of scientists; (5) social construction of scientific knowledge; (6) social construction of technology; (7) influence of school science on society, and (8) nature of scientific knowledge.

About the number of options and features of VOSTS items is well described by Aikenhead & Ryan (1992, p.484):

> *"The number of student positions for a VOSTS item typically varies between five and 13. Three additional choices are always added in order to represent other possible responses:*
>
> - *I don't understand.*
> - *I don't know enough about this subject to make a choice.*
> - *None of these choices fits my basic viewpoint.*
>
> *The last of these three will provide a measure of how well the student positions represent student viewpoints."*

The description above gives an overview about how each VOSTS item is constructed and structured, and one can make sense of it when using statements extracted from the pool of 114 VOSTS items.

The option for this instrument was because of its validity, making it a reliable instrument to measure students' opinions about STS issues, and its widespread use throughout the world.

For any study of students' beliefs and views about STS the VOSTS instrument is appropriate and used internationally on a wide scale as asserted by (Vasquez & Manassero, 1999, p.232): "*In recent research, VOSTS items have been widely applied to assess STS issues or to investigate conceptions about STS topics."* Furthermore, prior to this assertion, Acevedo (1996), based on Aikenhead (1992) claims, assured that VOSTS instrument is one of the most known and used to identify students' beliefs and views about STS.

4.4.1. The Widespread Use of VOSTS Instrument

Since the appearance of VOSTS instruments in science education in late 80s, almost three decades after the introduction of STS courses in science curricula of many countries, the instruments gained popularity in science education research. Because of that it has been used as prime research instrument in developed and developing countries to test students' views and beliefs about STS issues.

The VOSTS items have been used in countries with well established STS courses in science curricula for more than three decades, such as United States of America, Canada, and United Kingdom and Australia. Relatively recent countries that introduced STS courses in science syllabus, also used VOSTS items, as can be seen in the examples below:

- ***Ibero-America countries***: Spain (Manassero & Vasquez, 1998); Portugal (Nunes, 1996); and joint study by Alonso et al., (2010) covering the following Latin America countries:, Colombia, Argentina, Mexico and Portugal and Spain in Europe.
- ***Asia***: Taiwan (Lin & Chen, 2002); Brunei (Tairab, 2001); Turkey (Yalvac *et al,* 2007).
- ***Middle East***: Lebanon (Abd-El-Khalik & Boujaoude, 1997); United Arab Emirates (Haidar, 1999), Israel (Ben-Chaim & Zoller, 1991).
- ***Africa:*** Nigeria (Mbajiorgu & Ali, 2002); Egypt (Mansour, 2008)

Although not mentioned in the examples above there are countries where the STS is well established and many researchers have been undertaken using VOSTS instruments, for example: Australia, Netherland, Sweden, Germany; South Africa and Singapore.

The VOSTS Form CDN.MC 5 was developed over a period of six years based on responses of more than 5000 Canadian students from grade 11 and 12 across the country. To elucidate the nature of the VOSTS items that distinguish it from other instruments the designers of the instrument argue:

> *" VOSTS conveys students' ideas, not numerical scores. The domain of possible responses to a VOSTS item derives not from a theoretical or research-based viewpoint (as does the domain of distractors in a multiple-choice, for example) but empirically from the domain of student viewpoints."* (Aikenhead & Ryan, 1992, p.480).

When a research instrument is develop to measure conceptions, behavior or attitude should be submitted to a validity test to verify whether it assesses what it claims to assess. For VOSTS item a series of previous studies that used selected items of the instruments verified the validity of this instrument (Bottom & Brown, 1998; Vasquez *et al.*, 2006; Vasquez *et al.,* 2013), as clearly stated Vasquez *et al.,* (2006, p.685).

> *" The empirical development provides a warrant for content validity of the instrument, as well as the statements included in the items correspond to empirical position elicited from respondents."*

In addition, the features described above the test and re-test of the reliability of the instrument was demonstrated independently by Bottom & Brown (1998).

Based on worldwide and widespread use of VOSTS items to verify students' viewsand beliefs about STS issues, combined with its validity the instrument was considered suitable for the purpose of this study.

In science education research there are many other instruments used to measure students' conceptions.

A random selection made by the researcher show that the most used are shown in the table below:

Name of the instrument	Proponents and Year	Number and Type of Questions	Nature
1. TOUS (Test of Understanding of Science)	Cooley, W & Klopfer, L (1961)	60 multiple-choice test	NOS
2. SPI (Science Process Inventory)	Welch, wayne (1966)	135 items forced-choice (agree/disagree)	NOS
3. WISP (Wisconsin Inventory of Science Process Nature)	Wisconsin University (1967)	93 statements Likert-type (accurate/inaccurate/not understanding)	NOS
4. NOSS (Nature of Science Scale)	Kimbal, (1968)	29 statements forced-choice (agree/disagree)	NOS
5. NSKS (Nature of Scientific Knowledge Scale)	Rubba & Andersen (1976)	48 items with 8 items with sub-scale	NOS
6. BASSSQ (Beliefs about Science and Science School Questionnaire)	Aldrige, J; Taylor, P, Chin, C (1997)	41 items Likert-scale	NOS
7. VNSQ (Views of Nature of Science Questionnaire)	Lederman, N; Khalick; Bell, R; Schwart (2002)	Open-ended questions	NOS
8. VOSTS (Views of Science, Technology and Society)	Aikenhead; Fleming; Ryan (1987-1993)	114 multiple-choice questions	VOSTS
9. GSLQ (Global Scientific Literacy Questionnaire).	Deborah Pomeroy (1993)	50 items: agree/disagree statements on a 5 points likert-scale	VOSTS
10. NSTQ (Nature of Science and Technology Questionnaire)	Tairab & Hassam (2001)	8 items, (7 multiple-choice and 1 open-ended)	VOSTS

Table 11: Different Instruments used to measure opinions

NOS = Nature of Science VOSTS = Views of Science, Technology and Society

Other Instruments:

- ISTE = Introductory Science teacher education
- TOSRA = Test of Science Related Attitude
- ISTS = Inquiry Science Technology Strategies

As can be seen from the table above, in the recent years VOSTS items are still widely used to assess students' opinions about the nature of science. (Alonso & Manassero, 1999).

Of the 114 multiple-choice items of the VOSTS instrument this study used 19 of them from a preliminary choice of 22 items pre-selected, covering 6 of the 8 sections that comprises the pool.

By looking at other studies carried out using the VOSTS instruments it can be seen that there are some that used more or less number as shown in the examples below (the examples were chosen trying to represent different countries):

- Less VOSTS items: 6 items (Zoller & Donn, 1991); 8 items (Auler & Delizoicov, 2002).
- More VOSTS items: 16 items (Rubba, Bradford & Harkness, 1996); 20 items (Mbajiorgu & Ali, 2003); 26 items (Yalvac *et al.*, 2007); 29 items (Bottom & Brown, 1998); 31 items (Mack, Campbell & Abd-Hamid., 2008).

This study uses thirteen (13) VOSTS items selected, and this number is within the acceptable rage (12 to 18), as suggested by Aikenhead & Ryan (1992), because to respond to each VOSTS item requires a fair amount of reading.

4.4.2. Pilot Study

Before administering the VOSTS items to the target group in the baseline and in the intervention process a pilot study was conducted. To show the relevance of a and connection between the pilot study and the main study Lodico *et al.*, (2010, p.27), stated: "A pilot study involves the administration of the survey to a small group of individuals who help to work the 'kinks" out of the survey."

To stress the importance of the pilot study for the main study the Lodico *et al.,* (2010; p.27) argue:

> *"This process helps the researcher determine the survey's validity (refers to the degree to which the survey measures what it was intended to measure). and its reliability (refers to consistency of responses). "*

Taking these into account, and based on the VOSTS items to be used as the main research instrument, and in order to "trying-out" a research instrument (Baker, 1994), the following steps were taken:

First step: Selection of VOSTS items from the pool of 114 that could meet the goals of the study, taking into consideration the context of the country. This process yield 22 pre-selected VOSTS items covering as many areas as possible from the original pool.

Second step: Administration of the 22 pre-selected items to a group of 27 second year chemistry students in one of the branches. The respondents were supposed to have similar characteristics with those who would take part in the main study (Miles & Huberman, 1984; Cohen & manion, 2011; Denzin & Lincoln, 2011). After the administration as a follow up step an interview was conducted with some of the participants. This process yield the reduction of number of VOSTS items from 22 to 19, because some were considered repetitive.

Third step: Decide on the average number of VOSTS items to make up the questionnaire for survey and for the intervention process taking into account the average time to respond each question and the purposes of the survey and of the intervention.

The diagram below shows the process of selections and administration of VOSTS items in the survey and in the intervention process.

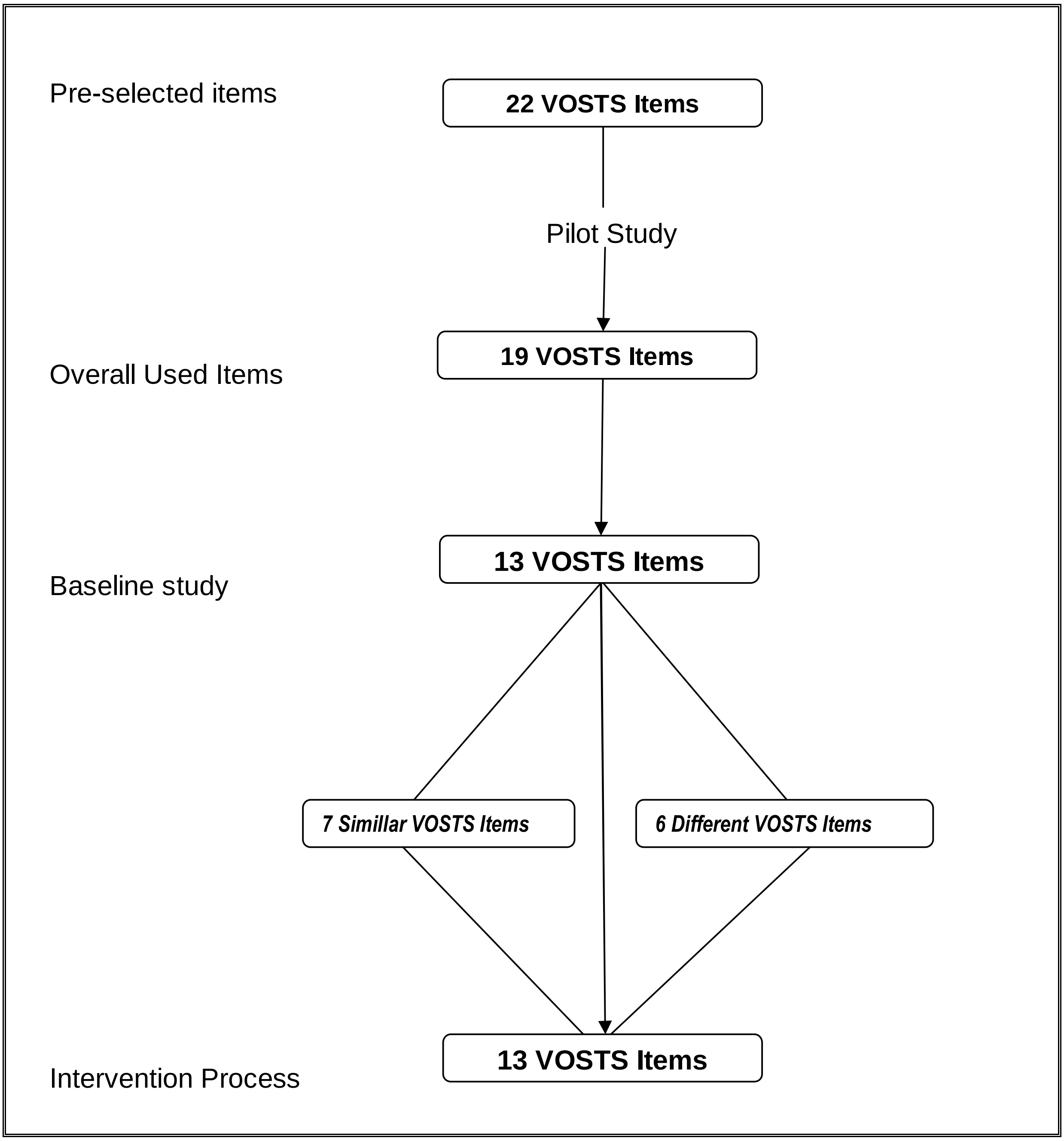

Figure 4: Process of Selection of VOSTS items

The diagram above shows that of the 22 pre-selected VOSTS items, after the pilot study 19 were selected for the study, and decision was made that students would only answered to 13 VOSTS items: 13 in the baseline study and 13 in the intervention process.

Of the 13 VOSTS items used in the baseline, 7 were used again in the intervention and other 6 were replaced by others considered suitable for the intervention. (See appendices 1 and 2 for the VOSTS items used in the baseline study and in the Intervention process, respectively).

As result of the piloting process it was possible to make the following decisions:

1. It was estimated that the average time taken by students to answer each question was 5 minutes, and to answer all 19 questions students would take in average 110 minutes.

2. The questions were very complex and sometimes required additional explanation in order to choose only one option as was required, especially in questions with two parts. A post-questionnaire interview to 4 students showed that the questions with two parts students were always tempted to choose two options, despite the clarity of the instruction on the cover of the questionnaire.

Based on these findings, and in order to make the administration of the questionnaire feasible in the context of the country the following decisions were taken:

1. The number of questions was reduced to be answered between 60 to 90 minutes - the average time used write a test in normal situation at university. Keeping the underlying assumption that guided the selection of the 19 questions, after a thorough analyze the questionnaire was reduced to 13 questions.

2. Between the survey and the intervention should be used the 13 questions. But, only 7 questions should be similar, with the baseline study emphasizing more on the influence of science and technology on society, while in the intervention process should be included 6 other questions related to the nature of scientific knowledge, that would derive from the practical work performed using inquiry type approach.

The baseline study and the intervention process were considered two independent processes in the study that have in common the use of VOSTS items as instruments, but not necessarily the same. The processes have different purposes, one is to establish the baseline situation of the country about STS issues, and the other is to ascertain whether the approach purposed is feasible within the scope of the intervention design made, STS approach by mean of inquiry type of practical work.

3. Need to explain and make clear to the students that they should choose only one options per question, even in the question with two opposite parts - Questions: Q_3 (20511), Q_5 (40311), Q_7 (40711), Q_{10} (90631), Q_{12} (91013) and Q_{13} (91121).

The outcome of the pilot study shade light into the final design and choice of the VOSTS items, as well as the instructions to give to the respondents. With these guiding ideas it was possible to administer the instrument to the two target groups: first, as baseline study to all second year students from all branches of science courses and science related courses - biology, chemistry, physics and agriculture , and secondly to the intervention group in two consecutive years (2012 and 2013), using second year chemistry students of one of the branches (Manica branch).

4.4.3. The VOSTS Items Used

The nineteen (19) VOSTS items used in the baseline study and in the intervention process, of which 7 were similar and 6 were different. The guiding principle in the selection of the items was to cover all the six (6) areas under which the 114 items are categorized. This goal was achieved because the 19 items used in this research 6 of the 8 sections were covered distributed in the following order:

(1). Basic definitions of science and technology ï 2 questions: Q_1 (10111), Q_2 (10211).

(2). Science and technology for the society ï 1 question: Q_3 (20511).

(3). Science and technology viewed in society ï 6 questions: Q_4 (40217), Q_5 (40311), Q_6 (40412), Q_7 (40441), Q_8 (40531), Q_9 (40611), Q_{10} (40711).

(4). Views of science in medias and science classes ï 1 question: Q_{11} (50313).

(5). Technology development and implementation ï 2 questions: Q_{12} (80122), Q_{13} (80211).

(6). Nature of science or how scientists do science ï 6 questions: Q_{14} (90111). Q_{15} (90611), Q_{16} (90631), Q_{17} (90711), Q_{18} (91013), Q_{19} (91121).

The table below summarizes the 19 items used classified according to the areas with the main statement made:

Nr.	Number	VOSTS Area Covered and Question Statement
		Basic Definitions of Science and Technology
01	**10111**	Defining science is difficult because science is complex and does many things. But MAINLY science is:
02	**10211**	Defining what technology is, can cause difficulties because technology does many things in Canada. But MAINLY technology is:
		External Sociology of Science: Influence of Science and Technology for the Society
03	**20511**	The success of science and technology in Mozambique depends on us having good scientists, engineers and technicians. Therefore Mozambique should require students to study more science in school.
		External Sociology of Science: Science and Technology viewed in Society
04	**40217**	Scientists and engineers should be the ones to decide on world food production and food distribution (for example, what crops to plant, where best to plant them, how to transport food efficiently, how to get those who need it, etc.) because scientists and engineers are the people who the facts best.
05	**40311**	We always have to make trade-offs (compromises) between the positive and negative effects of science and technology.
06	**40412**	Science and technology offer great deal of help in resolving social problems as poverty, crime and unemployment.
07	**40441**	In spite of their knowledge and training, scientists and technologists can be fooled by what they see on TV or read in newspaper.
08	**40531**	More technology will improve the standard of living of Mozambicans.
09	**40611**	The most powerful countries of the world have strength because of the country´s superior science and technology.
10	**40711**	Science and technology influence our everyday thinking because science and technology give us new words and ideas.
		External Sociology of Science: Views of Science in Medias and science Classes
11	**50313**	The mass media in general (TV, newspapers, magazines, movies, etc..) give *more* accurate picture of what science really is in Mozambique, compared to the picture offered by science classes.
		Internal Sociology of Science: Technology Development and Implementation
12	**80122**	When a new technology is developed (for example, a new medicine to fight cancer), it may or may not be put into practice. Decision to use a new technology depends on whether scientists have been able to explain why it works.
13	**80211**	Technological developments can be controlled by citizens.
		Epistemology: Nature of Scientific Knowledge.
14	**90111**	Scientific observations made by competent scientists will usually be different if the scientists believe different theories.
15	**90611**	When scientists investigate, it is said that they follow the scientific method. The scientific method is:
16	**90631**	Scientific discoveries occur as a result of a series of investigations, each one building on an earlier one, and each one leading logically to the next one, until the discovery is made
17	**90711**	Even when making predictions based on accurate knowledge, scientists and engineers can tell us only what *probably* might happen. They cannot tell what will happen for certain.
18	**91013**	For this statement, assume that a gold miner “discovers” gold while an artist “invents” a sculpture. Some people think that scientists *discover* scientific THEORIES. Others think that scientists *invent* them. What do you think?
19	**91121**[a]	Scientists in different fields look at the same thing from very different points of view (for example, H+ causes chemists to think of acidity and physicists to think of protons). This means that one scientific idea has different meanings, depending on the field a scientist works in

Table 12: The 19 VOSTS items used in the whole study

4.4.4. Translation of the VOSTS Items

The VOSTS instruments were developed in English, and by the time it was administered it was not available the Portuguese version of VOSTS. Later, after administering the questionnaire both in the baseline study and in the intervention it was found that, under an Ibero-American program there is Portuguese version of VOSTS that have been used in Portugal and Brasil for academic purpose known as *Questionário de Opiniões em Ciência, Tecnologia e Sociedade* (QOCTS) as well as Spanish version know as *Cuestionario de Opinions en Ciencia, Tecnologia y Sociedad* (COCTS). Roig et al., (2010).

Nevertheless, since by the time the research started the research did not have on hand and was not available a Portuguese version of the instrument, before administering it was necessary to translate to Portuguese the official language used as mean of instruction in the educational system of Mozambique.

In order to assure that the translation made was accurate and to minimize mistakes the translation was done in three stepwise and independent steps:

First Step: Translation made by the researcher himself, based on his background in both languages. He used both languages as medium of instruction, and has stronger skills in the target language (Portuguese).

Second Step: Two junior English teachers who teach English as second language at University, each independently translated the questions. Then the researcher combined the two versions translated and produced one version after an interview with them to sort out differences.

Third Step: Send the instrument for translation to two senior lecturers coordinating the English course at Pedagogical University, holding a PhD degree in English speaking countries.

By doing cross-check of these translations it was possible to come up with a final version of the instrument in Portuguese. after that the document was adapted by changing the word Canada with Mozambique, and then it was adopted as the main research instrument to be administered to the target group for the study.

The survey was conducted in all branches of the Pedagogical university targeting second years students of four courses. The table below summarizes the participants in the survey.

4.4.5. Scoring Scheme for VOSTS Items

To assess students' responses on the selected VOSTS items for baseline study and intervention process was necessary to devise a memorandum schedule. With it would be possible to fit each options into the category devised.

Several scoring scheme for complex multiple-choice items have been suggested to improve the scope of quantitative analysis. The table 13 bellow summarizes some.

Number of Categories	Proponent	Categories
3 Categories	Rubba *et al* (1996)	• Naïve • Has Merit • Realistic
	Alonso & Manassero (1999)	• Naïve • Plausible • **Appropriate**
	Manassero *et al.* (2005)	• Naïve • Plausible • Acceptable
4 Categories	Tedman & Keeves (2001)	• Naïve • Beginning to get past naïve ideas • Shows awareness of STS ideas • Sophisticated

Table 9: Different categories of scoring scheme

Despite discrepancies in the number of categories, and differences in the name the meaning are almost the same, the three categories scoring looks at the choice compared with the view accepted in the scientific community while the four categories scoring looks the choice within the scope of the STS itself.

Despite critiques about philosophical demerit and incoherence on the use of words (some categories use one word and others two to name them), as pointed out by Alonso and Manassero (1999), this research the three categories model proposed by Ruba et al., (1996) will be adopted because it is more in line with the purposes of the study. Below is described the meaning of each category:

- Naïve (N) = the choice expresses a view that is inappropriate or not legitimate. The same name and meaning were suggested by Alonso and Manassero (1999) and by Manassero et al., (2005).
- Has Merit (HM) = while not realistic, the choice expresses a number of legitimate points. The same meaning is used for the category Plausible suggested by Manassero et al., (2005), and by Alonso and Manassero (1999).

- Realistic (R) = the choice expresses an appropriate view. The same meaning is used for the category Acceptable suggested by Manassero et al., (2005) or Appropriate by Alonso and Manassero (1999).

In order to devise a scoring scheme to assess students' responses was necessary to assemble a panel of experts, usually people who work with STS course or acquitted with STS approach. The panel of experts had a task to make the scoring scheme using pre-defined categories.

The use of panel of experts to make a scoring scheme for VOSTS items was first suggested by the inventors of the instrument and have been used in several studies (Ben-Chaim & Zoller, 1991; Rubba, *et al*, 1996; Bottom & Brown, 1998; Tedman & Keeves, 2001; Lederman et al., 2014). The number of judges vary, but invariably they try to pick up prominent scholars in the field, and the consensus is reached either by confrontation via interview or the majority criterion.

The experts assembled to make the scoring scheme for this research were asked to do so based on the three categories suggested by Rubba, after receiving the meaning of each of them.

For this purpose a panel of 6 judges experts (one foreigner from Germany and 5 from UP in Mozambique) was assembled to establish a scoring scheme. The experts were senior lecturers, with PhD degree and more than 25 experience working at university in different subjects. They are senior lecturers and the most experienced in their subjects at the Pedagogical university in Mozambique, but were not acquitted with STS approach, except the one expert from the Germany. The experts were from the following fields: chemistry (4 experts), biology one and one from physics.

To score the 13 VOSTS items each expert was given the 13 VOSTS items with all the options, excluding the last three options that are similar to all questions: *(1) I don't understand*; *(2) I don't know enough this subject to make a choice* and *(3) None of these choices fits my basic view point.* For these three categories this research adopted the label Passive (P), meaning that the student did not take active role on choosing other options. This designation was first suggested by Ben - Chaim & Zoller (1991).

Therefore, in this research a four category scoring scheme will be used: Passive (P); Naïve (N), Has Merit (HM) and Realistic (R).

The task assigned to them was to select only one option that they consider ***Realistic*** and could classify other options as ***Has Merit*** or ***Naïve*** more than one time. As a result of this process, each expert come up with a scoring scheme for all the 13 questions.

For the six (6) questions that were only used in the baseline study, another group of four experts from the Pedagogical University, holding PhD degree was assembled with the same task. They were from Mathematics (3) and one from French course, all of them with more than 15 years experience working at university in different subjects of their field. They were also not acquitted with STS courses or STS issues.

There were discrepancies on the choice of Realistic view, as well as in the classification of other options as Has Merit and Naïve made by the experts. To sort out those discrepancies, in order to have the final scoring scheme the criterion used was to choose the most chosen options among the experts, and for the same VOSTS items used by other researchers, the option was to adopt their scoring scheme, specially on the choice of the realistic view.

The table below shows the final scoring scheme for all 19 VOSTS items used both in the baseline study and in the intervention**.** (See appendix 3 for the 13 VOSTS items categorized by the first group of 6 experts and the appendix 4 for the 6 VOSTS categorized by the group of 4 experts).

Item	Category			
	Realistic	Has Merit	Naïve	Passive
Q_1: 10112*	C	ABF	DEG	HIJ
Q_2: 10211*	G	BDEF	A	HIJ
Q_3: 20511*	C	ABCD	EFG	IJK
Q_4: 40217*	D	CEF	ABG	HIJ
Q_5: 40311*	C	AGD	EFH	IJK
Q_6: 40412 [b]	D	ABC	EF	GHI
Q_7: 40441 [b]	C	ACE	BD	FGH
Q_8: 40531 [b]	F	ACE	BD	GHI
Q_9: 40611*	E	BCD	F	GHI
Q_{10}: 40711*	D	BCE	F	GHI
Q_{11}: 50313 [b]	E	CFGH	ABD	IJK
Q_{12}: 80122 [b]	E	BGF	AC	GHI
Q_{13}: 80211 [b]	E	ABCDF	G	HI
Q_{14}: 90111 [i]	B	AC	DE	FGH
Q_{15}: 90611 [i]	G	HIJ	ABCDEF	KLM
Q_{16}: 90631 [i]	D	ABCE	FG	HIJ
Q_{17}: 90711 [i]	A	BE	CD	FGH
Q_{18}: 91013 [i]	D	EF	ABC	GHI
Q_{19}: 91121 [i]	B	AD	CE	FGH

Table 10: Experts' categorization of questions

***** = 7 Questions used both in baseline and in intervention.
[b] = 6 Questions used only in the baseline study.
[I] = 6 Questions used only in the intervention.

Irrespective of the number of categories used to classify the choices made by respondents of VOSTS item there are two main types of scoring scheme to assess responses to VOSTS items:

- unique Response Model (URM): in which respondents are required to choose only one correct option, and all others are left aside.
- multiple Response Model (MRM): based on likert-type scale of 5 or 7, where each option is rated from negative to positive position.

The main critique to the URM is for its limiting scope to make use of rich information provided by the instrument. Furthermore, it seems that the VOSTS items were more focusing on qualitative side by identifying type of conceptions. The attempt made by Rubba et al., (1996) to devise a numerical scale to their three categories model R/HM/N in order to use the results for inferential statistic. This attempt to full explore the potential of the instrument was continued by Alonso and Manassero (1999), moving a step further by criticizing the URM and proposing a likert-type scale expanded the scope of VOSTS items in inferential statistics. They pointed out:

> *"the Unique response model usually applied to answer VOSTS items does not allow the use of inferential statistic and does not take advantage of the large volume of available information."* (Alonso & Manassero, 1999, p.231).

While this criticism about the URM is legitimate, this study will still use the URM because it is more in lines with the aim of the study, which is to identify students' opinions and find out in which of the four categories devised fall the three most chosen options, rather than evaluate the nature of choices made by students, or make extensive exploration of inferential statistic from the data yield.

Chapter V: RESULTS AND DISCUSSION OF DATA FROM THE SURVEY

With the research paradigm and methodology presented in the previous chapter, this chapter presents and discusses the data gathered using one of the instruments used. This chapter presents and discusses the data collected from the administration of the thirteen (13) VOSTS item questionnaire administered to the ten (10) branches of the Pedagogical University in Mozambique.

The chapter starts by showing the 13 VOSTS items selected for the survey, and then presents the scoring scheme devised by the panel of experts and used to assess students' responses. The final part of the chapter comments each of the 13 VOSTS items responses obtained from the survey.

The discussion of each of the 13 items will use descriptive statistic, because the data was presented and described in terms of summary frequencies, and make no inferences or predictions based on numbers (Larson & Farber, 2010; Denzin & Lyncoln, 2011; Cohen & Manion, 2011).

5.1. The VOSTS Items Used in the Survey

As it was presented in the previous chapter, the survey was conducted in all ten (10) branches of the Pedagogical University of Mozambique, using a sample of 832 second year students enrolled in science and science related course, namely: agriculture, biology, chemistry and physics.

The table below shows the number of students who participated in the survey

Course	Participants	Frequency (%)
Agriculture	145	17.4%
Biology	286	34.4%
Chemistry	236	28.4%
Physics	165	19.8%
Total:	**832**	**100%**

Table 15: Number of participants in the survey per course

For the purpose of this study is not important to identify students' answer pattern according to branch where they belong to. Instead, students' responses to the 13 VOSTS items that comprise the questionnaire, will be assessed by comparing the patterns across the four courses.

The table below shows the 13 VOSTS items used in the survey, classified into five (5) areas covered:

Nr.	VOSTS Number	VOSTS Area Covered and Question Statement
		Basic Definitions of Science and Technology
01	10111	Defining science is difficult because science is complex and does many things. But MAINLY science is:
02	10211	Defining what technology is, can cause difficulties because technology does many things in Canada. But MAINLY technology is:
		External Sociology of Science: Influence of Science and Technology for the Society
03	20511	The success of science and technology in Mozambique depends on us having good scientists, engineers and technicians. Therefore Mozambique should require students to study more science in school.
		External Sociology of Science: Science and Technology viewed in Society
04	40217	Scientists and engineers should be the ones to decide on world food production and food distribution (for example, what crops to plant, where best to plant them, how to transport food efficiently, how to get those who need it, etc.) because scientists and engineers are the people who the facts best.
05	40311	We always have to make trade-offs (compromises) between the positive and negative effects of science and technology.
06	40412	Science and technology offer great deal of help in resolving social problems as poverty, crime and unemployment.
07	40441	In spite of their knowledge and training, scientists and technologists can be fooled by what they see on TV or read in newspaper.
08	40531	More technology will improve the standard of living of Mozambicans.
09	40611	The most powerful countries of the world have strength because of the country´s superior science and technology.
10	40711	Science and technology influence our everyday thinking because science and technology give us new words and ideas.
		External Sociology of Science: Views of Science in Medias and science Classes
11	50313	The mass media in general (TV, newspapers, magazines, movies, etc..) give *more* accurate picture of what science really is in Mozambique, compared to the picture offered by science classes.
		Internal Sociology of Science: Technology Development and Implementation
12	80122	When a new technology is developed (for example, a new medicine to fight cancer), it may or may not be put into practice. Decision to use a new technology depends on whether scientists have been able to explain why it works.
13	80211	Technological developments can be controlled by citizens.

Table 11: The VOSTS Items used in the survey and areas covered

For each item students were asked to choose only one of the options given which best suited their view or believe about the statement.

In order to assess and discuss students' responses the categorization for each option of the question devised by the panel of experts will be used as the scoring scheme. The table below shows the scoring scheme devised by the experts and adopted to assess students' responses:

Item	Category			
	Realistic	Has Merit	Naïve	Passive
Q_1: 10112[a]	C	ABF	DEG	HIJ
Q_2: 10211[a]	G	BCDEF	A	HIJ
Q_3: 20511[a]	C	ABCD	EFGH	IJK
Q_4: 40217[a]	D	CEF	ABG	HIJ
Q_5: 40311[a]	C	ABGD	EFH	IJK
Q_6: 40412	D	ABC	EF	GHI
Q_7: 40441	C	ACE	BD	FGH
Q_8: 40531	F	ACE	BD	GHI
Q_9: 40611[a]	E	ABCD	F	GHI
Q_{10}: 40711[a]	D	ABCD	F	GHI
Q_{11}: 50313	E	CFGH	ABD	IJK
Q_{12}: 80122	E	BGF	AC	GHI
Q_{13}: 80211	E	ABCDF	G	HI

Table 12: Experts' categorization of VOSTS item used in the survey

[a] = VOSTS item categorized in other studies and adopted in this study.

This scoring scheme is the same as the one presented in table 10 in previous chapter, but it focus on the questions used in the baseline study.

The discussion of each of the VOSTS items will be done taking into account two criteria:

- First: use the scoring scheme devised by the panel of experts and the literature, based on four categories: *Realistic/ Has Merit/ Naïve/ Passive* to assess students' responses. Then, based on the findings, try to find out whether there is significant difference or not across the four courses, based on *chis-square* test results applying the SPSS statistical package, version 20.
- Second: use the students' responses pattern (the three most selected options in each VOSTS item) and find out what is the underlying beliefs or views. This will be done by using the VOSTS conceptual scheme devised by the precursors of the VOSTS instruments (Aikenhead & Ryan, 1992).

Based on these two approaches it is possible to identify not only what students' conceptions and beliefs are about STS, but also the category of these concepts and beliefs, based on the current knowledge of science in the fields represented by each of the 13 VOSTS items selected in this study.

5.2. Students' Views and Beliefs about STS

This sub-chapter presents and discusses students' responses to each of the 13 VOSTS items used in the baseline study, representing students views and beliefs about STS issues.

The approach used is presenting a table containing students' responses in each of the options of VOSTS statement per course so that the reader can perceive the choice made, and in the last column can see how it was categorized according to scoring scheme assigned by the panel of the experts with the letters: **R** = Realistic; **HM** = Has Merit; **N** = Naïve and **P** = Passive.

Then, a graph is used to show the same results presented in the table in order to see differences across the courses, and finally, below the table and graph, an interpretation is given to the data presented by referring the three most chosen options per course and compare them with the categorization made by the panel of experts (See appendices 5 and 6 for full students' responses).

5.2.1. Students' Views about Definition of Science

This section gives students' opinions about the definition of science. Excluding the last three options presented in the table below, the other seven statements (A to H) encompass views of science as: an instrument, curiosity satisfaction; social enterprise and no definition for science.

Q1: 10111. Defining science is difficult because science is complex and does many things. But MAINLY science is: Your position, basically: (Please read from A to K, and then choose one.)	**% per Course**				**Category**
	Bio. % (N=286)	**Chem. % (N=236)**	**Phys. % (N=165)**	**Agr. % (N=145)**	
A. A study of fields such as biology, chemistry and physics.	10.5	7.2	3.9	5.4	HM
B. A body of knowledge, such as principles, laws and theories, which explain the world around us (matter, energy and life).	36.7	50.0	48.3	29.2	HM
C. Exploring the unknown and discovering new things about our world and universe and how they work.	22	19.1	20.6	27.7	**R**
D. Carrying out experiments to solve problems of interest about the world around us.	9.1	8.9	7.8	9.2	N
E. Inventing or designing things (for example, artificial hearts, computers, space vehicles).	0.3	0.2	0.6	3.1	N
F. finding and using knowledge to make this world a better place to live in (for example, curing diseases, solving pollution and improving agriculture).	6.3	5.5	5.6	13.2	HM
G. An organization of people(called scientists) who have ideas and techniques for discovering new knowledge.	4.2	1.3	3.9	3.8	N
H. No one can define science.	4.2	2.1	3.9	2.3	N
I. I don't understand.	0.7	0.2	0.0	0.8	P
J. I don't know enough about this subject to make a choice.	1.0	1.3	1.1	1.5	P
K. None of these choices fits my basic viewpoint.	4.9	3.0	4.4	3.1	P

Table 13: Students' responses about definition of science

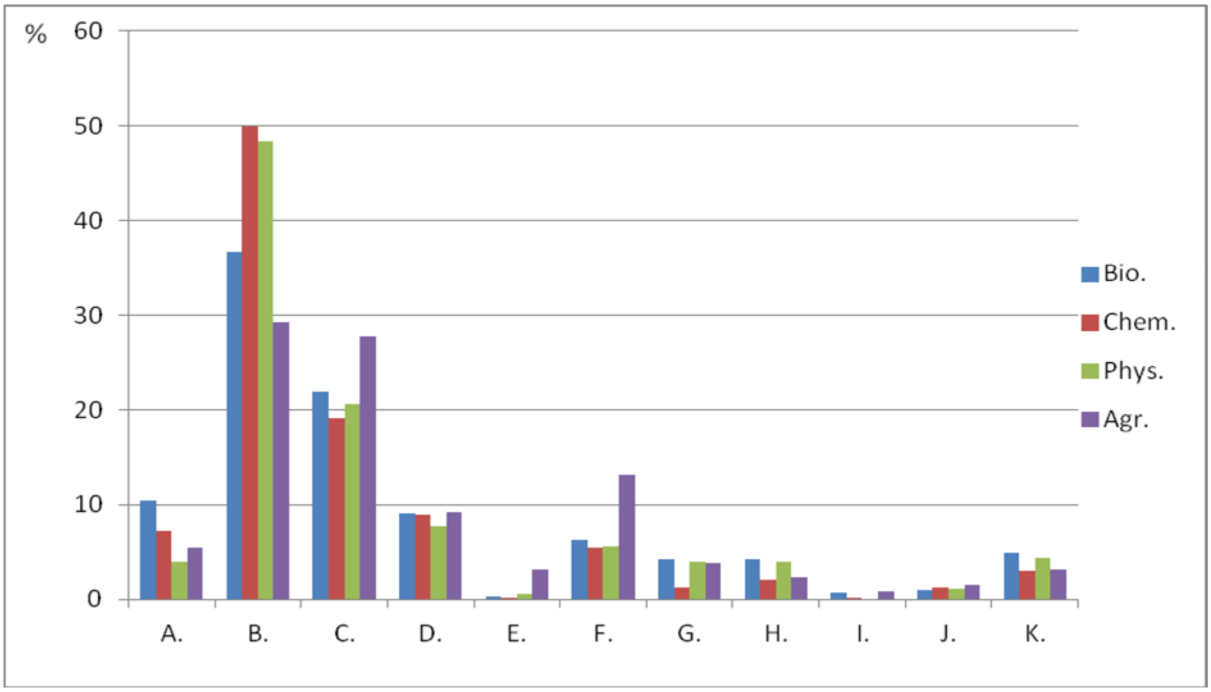

Figure 5: Students' responses about definition of science

From the data presented in the table 18 and in the graph above it can be seen that the first three choices across the four courses had the same pattern. The first most chosen option was B, followed by the option C, and in third place was the option D.

According to the categorization made by the experts, the option C, the second most chosen is considered a Realistic view, while the first and third most chosen options are considered Has Merit.

The option C, the first choice made across the four courses, encompasses the idea of science as an instrument and is more in line with a view of science as body of knowledge or a product. A possible explanation for this view hold by students is the nature of science content and curricula in Mozambican secondary school. This option, although it has a number of legitimate issues about science it embodies a canonical science (Aikenhead, 2005) in opposition to the view of science seeking for answers for curiosity satisfaction (science as a process) portrayed in option C, considered the most appropriate view of science.

Interestingly, in comparison to other three natural science courses, there is relatively high number of students of agriculture course (13.2%) who chose the option F, that encompasses the idea of science as social enterprise in which its body of knowledge is applied to make the world better. It seems possible that this view arise from the nature of agriculture course in which students are more in contact with the population and more concerned, among other issues, in better harvesting the crops to improve the standard of living, therefore they might be sensible to social part of science than their counterpart from other natural science.

In summary, in this study students' views about science is more like an instrument or like a finished product rather than as ***a process or something intrinsic to human nature to explore the unknown*** - a view commonly accepted in the scientific community. This view about science might be related to the nature of science curriculum taught in Mozambican secondary school, namely: separated science disciplines (biology, chemistry and physics), and the approach used to treat the contents of these disciplines that is more academic than the relevance of the contents to the students.

5.2.2. Students' views about Definition of Technology

This section gives students' opinions about the definition of science. Excluding the last three options presented in the table below, the seven statements (A to G) encompass view of technology as: application of science, hardware; something social and done for human purposes; socio-economic and cultural components, and something like science.

Q2: 10211. Defining what technology is, can cause difficulties because technology does many things in Mozambique. But MAINLY technology is: Your position, basically: (Please read from A to J, and then choose one.)		**% per Course**				**Category**
		Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
A.	Very similar to science.	4.2	2.5	2.8	7.7	N
B.	The application of science.	28.3	30.5	37.2	26.2	HM
C.	New processes, instruments, tools, machinery, appliances, gadgets, computers, or practical devices for everyday use.	45.1	42.4	34.4	36.9	HM
D.	Robotics, electronics, computers, communication systems, automation, etc..	6.3	3.4	2.8	3.8	HM
E.	A technique for doing things, or a way of solving practical problems.	9.8	10.2	10.6	13.1	HM
F.	Inventing, designing and testing things (for example, artificial hearts, computers, space vehicles).	0.3	1.3	3.9	0.8	HM
G.	Ideas and techniques for designing and manufacturing things, for organizing workers, business people and consumers, for the progress of society.	2.4	4.2	2.2	8.5	**R**
H.	I don't understand.	1.4	1.3	2.8	2.3	P
I.	I don't know enough about this subject to make a choice.	1.0	1.7	1.1	0.0	P
J.	None of these choices fits my basic viewpoint.	1.0	2.5	2.2	0.8	P

Table 14: Students' responses about definition of technology

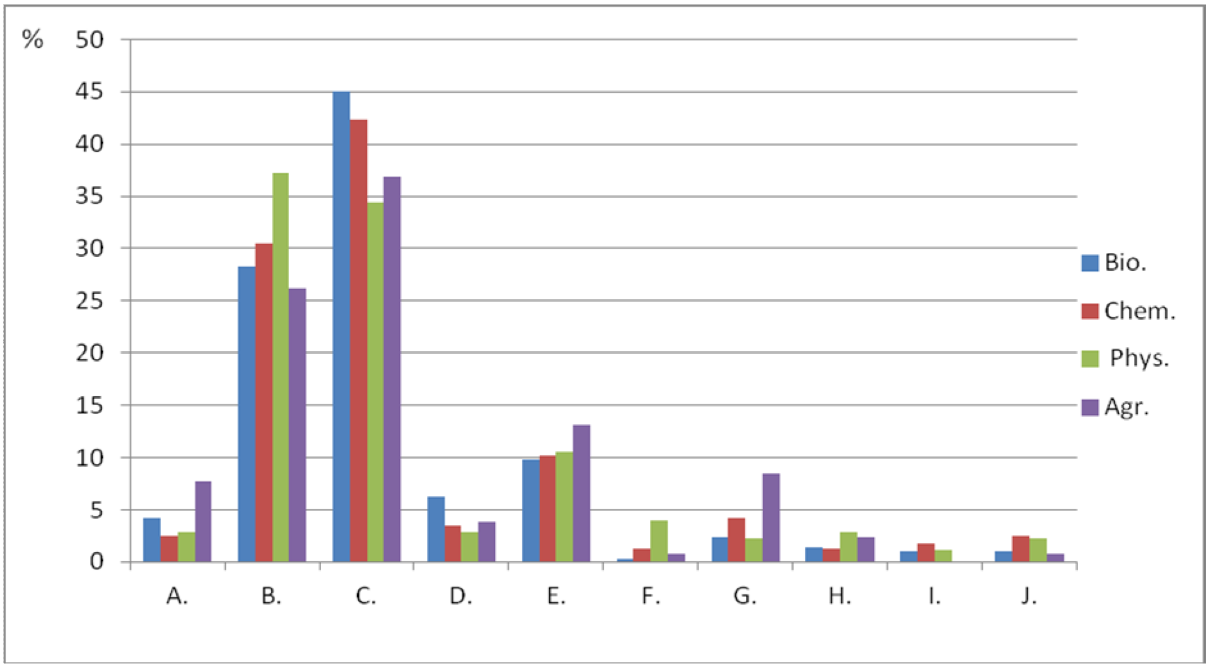

Figure 6: Students' responses about definition of technology**.**

From the data presented in the table 19 and in the graph above it can be seen that the option C was the most chosen in three courses: biology, chemistry and agriculture, while the option B was the most preferred in physics course. Both options are considered Has Merit.

The option B, was the second most chosen in the cluster of the three courses (biology, chemistry and agriculture), while for the physics course the second most chosen option was C. As referred above both options are considered Has Merit.

It is important to note that in this VOSTS item, the option G, considered Realistic view is not among the four first choice made in all four courses. A possible explanation for these results may be the lack of adequate knowledge about the definition of technology. In fact, the view of technology as the application of science is one of the common reductionist conception of technology.

The option C, the most chosen in three courses except in physics, encompasses the idea of technology as something social and done for human purpose it has some legitimate issues about the technology, but is not the appropriate view, according to the categorization made by the experts.

Interestingly, in the physics course the option B, technology as the application of science, was the first choice unlike other three courses. It seems possible that these result may be due the nature of physics curriculum in which different instruments and apparatus used in a traditional laboratory, are to support or prove scientific laws, theories and principles.

To corroborate this finding based on the Mozambican context, using the same VOSTS item, the preference for option B was also found in a study carried out in England by Bottom & Brown (1998), using 29 post-graduate trainees science teachers.

It might be true at certain stage of the development of the humanity that technology seems to be the application of science, in the current affairs both are so interconnected that it is difficult to conceive one without another (AAAS, 1990; p.36):

> *" As technologies become more sophisticated, their links to science become stronger* **é** *New technology often requires new understanding, new investigations often require new technology. "*

This is what is accepted in scientific community about the interdependence between science and technology, and it can be assumed that it is difficult to be grasped by Mozambican students or elsewhere, therefore understandable the answer pattern in which technology is viewed as subordinated to science.

In summary, students' views about the definition of technology are based on misconceptions, in which they hold the idea of technology as something social done for human purposes and is also viewed as the application of science. The most appropriate view should be seeing technology as **conception and manufacturing things for human purposes and for the progress of society.**

5.2.3. Students' opinions about Whether Success in Science and Technology Depends on more Science in School

In this section students' give their opinions about schools require more science to have success on science and technology. Excluding the last three options presented on the table below the eight statements (A to H) encompass two opposite positions: the first that advocates that science should be mandatory, and the second that advocates that science should not be mandatory.

Q3: 20511 The success of science and technology in Mozambique depends on us having good scientists, engineers and technicians. Therefore, Mozambique should require students to study more science in school. Your position, basically: (Please read from A to K, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
Students should be required to study more science:					
A. Because it is important for helping Mozambique to keep up with other countries.	28.0	1.0	27.2	25.4	HM
B. Because science affects almost every aspect of society. As in the past our future depends on good scientists and technologists.	32.2	44.5	33.3	40.0	HM
C. Students should be required to study more science, but a different kind of science course. Students should learn how science and technology affect their everyday lives.	28.3	22.9	25.0	22.3	**R**
Students should NOT be required to study more science:					
D. Because other school subjects are equally or more important to Canada's successful future.	2.4	5.1	5.6	1.5	HM
E. Because it won't work. Some people don't like science. If you force them to study it. it will be a waste of time and will turn people away from science.	1.4	1.7	2.2	3.1	N
F. Because not all students can understand science, even though it would help them in their life.	3.1	5.5	1.7	0.0	N
G. Because not all students can understand science. Science is not really necessary for everyone.	1.0	0.8	1.1	0.0	N
H. Because it's not right for someone else to decide if a student should take more science.	1.4	0.8	1.7	4.6	N
I. I don't understand.	1.0	0.0	0.6	0.0	P
J. I don't know enough about this subject to make a choice.	0.3	0.8	1.5	1.5	P
K. None of these choices fits my basic viewpoint.	0.7	2.5	0.6	1.5	P

Table 15: Students' responses about whether the success in science and technology is due to more science in school

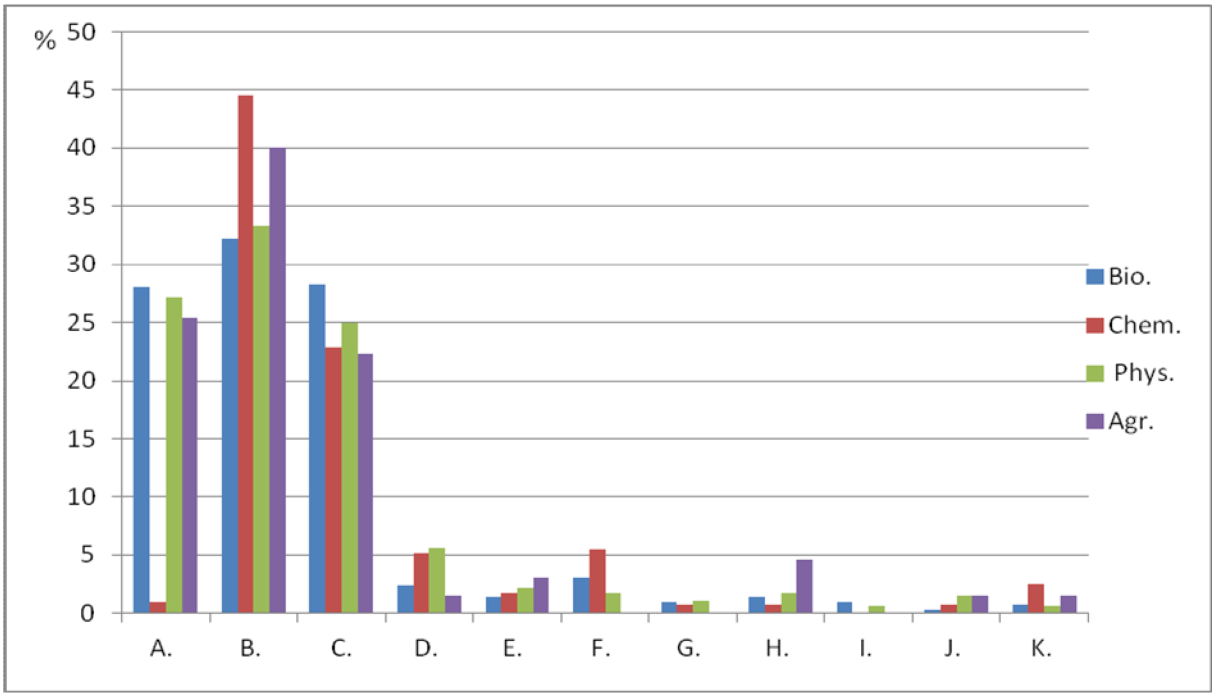

Figure 7: Students' responses about whether the success in science and technology is due to more science in school

From the data presented in the table 20 and in the graph above it can be inferred that in all four courses the option B was the first choice and is considered Has Merit view. The second most chosen option was A for physics and agriculture course, and was C for biology and chemistry course. While the option C is considered Realist view, the option A is considered Has Merit.

The Third choice for physics and agriculture course was the option C, above referred as Realistic view, while for biology and chemistry course the third most chosen category was F, considered by the panel of judges Naïve view.

Taken together, these results suggest that in all four courses students believe that science should be mandatory in school. The prime reason for this assertion, presented by choosing the option B, is because of its impact in our lives in the past and in the future. This choice contains some legitimate issues about why science should be mandatory at school, but the most appropriate choice (option C) should be because of the unhappiness with the current science taught at school.

These results are more likely to show how school science and curricula is perceived by students in Mozambican schools, based on canonical science (Aikenhead, 2005), rather than more meaningful and relevant science content. The discontent with

school science is a worldwide trend phenomenon, occurring in developing and developed countries, and is used as a rationale for many
studies and for introduction of new introduction of new teaching approaches and methodology.

In summary, in regard to the opinion about whether having good scientists and technologists is directly related to having more science content in school curriculum, students' believe can be considered acceptable because they support the idea that school science should be mandatory at school mainly because it has been always like that and science affects our live. Their believes are based on the external effect of school science taught, rather than dissatisfaction with the current science content taught at school.

5.2.4. Students' opinions about the Leading Role of Scientists and Technologists to Social Decisions

This section gives students' opinions about scientists' and engineers' role on decision-making about food production and distribution. The seven statements (A to G), excluding the last three, encompass three broad positions: technocratic or expert testimony; democratic decision-making (participation of all social stakeholders) and moral and legal decisions.

Q4: 40217. Scientists and engineers should be the ones to decide on world food production and food distribution (for example, what crops to plant, where best to plant them, how to transport food efficiently, how to get food to those who need it, etc.) because scientists and engineers are the people who know the facts best. Your position, basically: (Please read from A to J, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
Scientists and engineers should decide:					
A. Because they have the training and facts which give them a better understanding of the issue.	9.1	11.0	16.1	14.6	N
B. Because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests.	14.3	11.0	10.0	12	N
C. Because they have the training and facts which give them a better understanding; BUT the public should be involved either informed or consulted.	26.2	28.0	24.4	26.9	HM
D. The decision should be **made equally**; viewpoints of scientists and engineers, other specialists, and the informed public should all be considered in decisions which affect our society.	32.2	30.1	28.9	23.8	**R**
E. The **government** should decide because the issue is basically a political one; BUT scientists and engineers should give advice.	3.1	4.7	5.0	2.3	HM
F. The **public** should decide because the decision affects everyone; BUT scientists and engineers should give advice.	3.5	3.8	3.3	4.6	HM
G. The **public** should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic and narrow views on the issue and thus pay little attention to consequences.	3.1	3.0	2.8	3.8	N
H. I don't understand.	2.8	2.1	2.8	2.3	P
I. I don't know enough about this subject to make a choice.	3.5	3.8	3.9	5.4	P
J. None of these choices fits my basic viewpoint.	1.7	2.5	2.2	2.3	P
	0.3	0.0	0.6	1.5	

Table 16: Students' responses about the contribution of scientist and technologists to social decisions

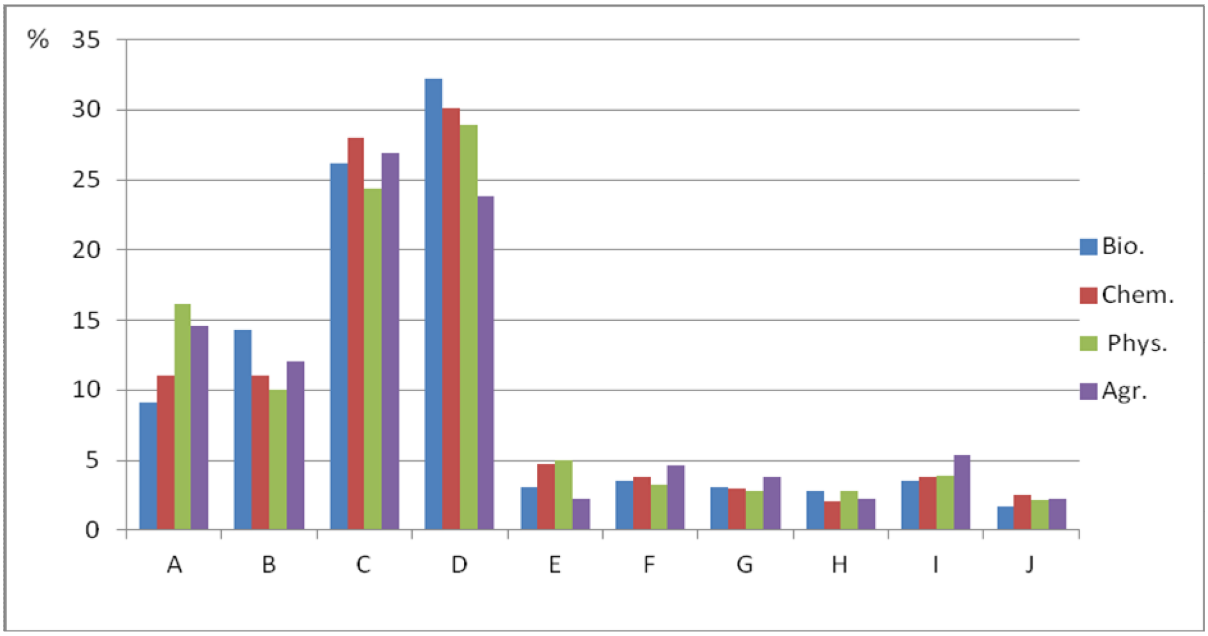

Figure 8: Students' responses about the contribution of scientist and technologists to social decisions

From the data presented in the table 21 and in the graph above it can be seen that the option D was the first choice in three science courses: biology, chemistry and physics, while the option C was the most preferred. While the first choice made by the cluster of three science course is considered Realistic view, the one made by the agriculture course is considered Has Merit.

The option C was the second most chosen the cluster of three science courses, while for the agriculture course as the option D. It was referred above that the former is categorized as Has Merit and the later as Realistic view.

The third most chosen option was A for biology and chemistry course, and for physics and agriculture it was B. Both option are categorized as Naïve View.

This question looks at the role of three different stakeholders on decision making about social issues: (1) the scientists/technologists - technocratic decision; (2) the government - moral and legal decision, and (3) the public - democratic decision.

From the answers presented it can be inferred that the option D, the most chosen in the three natural science courses, advocate the public participation equally with other stakeholders on decision-making about social issues. This is the appropriate view and is the ideal in democratic values that most countries are striving to construct. Other options that give leading role to scientists/ technologists or to government can threaten the participation of society on issues that matter to them.

The result in this study is different from the ones obtained in Germany (Schallies et al., 2001), using the same VOSTS item where about 3000 students aged 9 to 21 years, the most preferred option was C (technocratic decision - giving leading role to scientists/technologists on decision making about social issues).

It is quite surprising that a country Mozambique that was ruled under centralized government since independence in 1975, and with little more than two decades of multiparty system and democratic regime students view the equally share of responsibility between the public and other stakeholders is the best way to deal with social problems. It would be expected to see students' opinions backing or rely solely on scientists/technologists or government institutions.

In summary, students' opinions about the contribution of scientists and technologists to social decision about food production and distribution can be considered acceptable. Their believes are based on the assertion that it should not only be the responsibility of scientists and technologists, but the decision should be equally shared with other stakeholders like government and public. This is a democratic approach to the decision-making on the issues that matter the society and it is considered an appropriate view.

5.2.5. Students' opinions about the Influence of Science and Technology on Creation or Solution of Social Problems

This section gives students' opinions about whether should or shouldn't have compromises between the positive and negative effects of science and technology. The eight statements (A to H) presented in the table below, excluding the last three options, encompass two broad positions: The first is that there are always trade-offs, and the second one is that there are not always trade-offs.

Q 5: 40311 We always have to make trade-offs (compromises) between the positive and negative effects of science and technology. **Your position, basically:** (Please read from A to K, and then choose one.)	% per Course				Category
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
There are always trade-offs between benefits and negative effects:					
A. Because every new development has at least one negative result. If we didn't put up with the negative results, we would not progress to enjoy the benefits.	32.5	31.4	30.0	23.8	HM
B. Because scientists cannot predict the long-term effects of new developments, in spite of careful planning and testing. We have to take the chance.	9.1	7.2	7.8	13.8	HM
C. Because things that benefit some people will be negative for someone else. This depends on a person s viewpoint.	21.7	16.9	19.4	16.2	**R**
D. Because you can't get positive results without first trying a new idea and then working out its negative effects.	10.1	11.0	12.2	13.8	HM
E. But the trade-offs make no sense. (For example: Why invent labour saving devices which cause more unemployment? or Why defend a country with nuclear weapons which threaten life on earth?)	5.2	3.4	4.4	8.5	N
There are NOT always trade-offs between benefits and negative effects:					
F. Because some new developments benefit us without producing negative effects.	0.3	2.1	1.1	0.8	N
G. because negative effects can be **minimized** through careful planning and testing.	9.8	16.9	15.0	10.8	HM
H. Because negative effects can be **eliminated** through careful planning and testing. Otherwise, a new development is not used.	3.1	3.4	4.4	2.3	N
I. I don't understand.	2.1	1.7	2.2	1.5	P
J. I don't know enough about this subject to make a choice.	5.2	3.0	2.2	6.9	P
K. None of these choices fits my basic viewpoint.	0.7	3.0	2.2	1.5	P

Table 17: Students' responses about the influence of science and technology on creation or solution of social problems

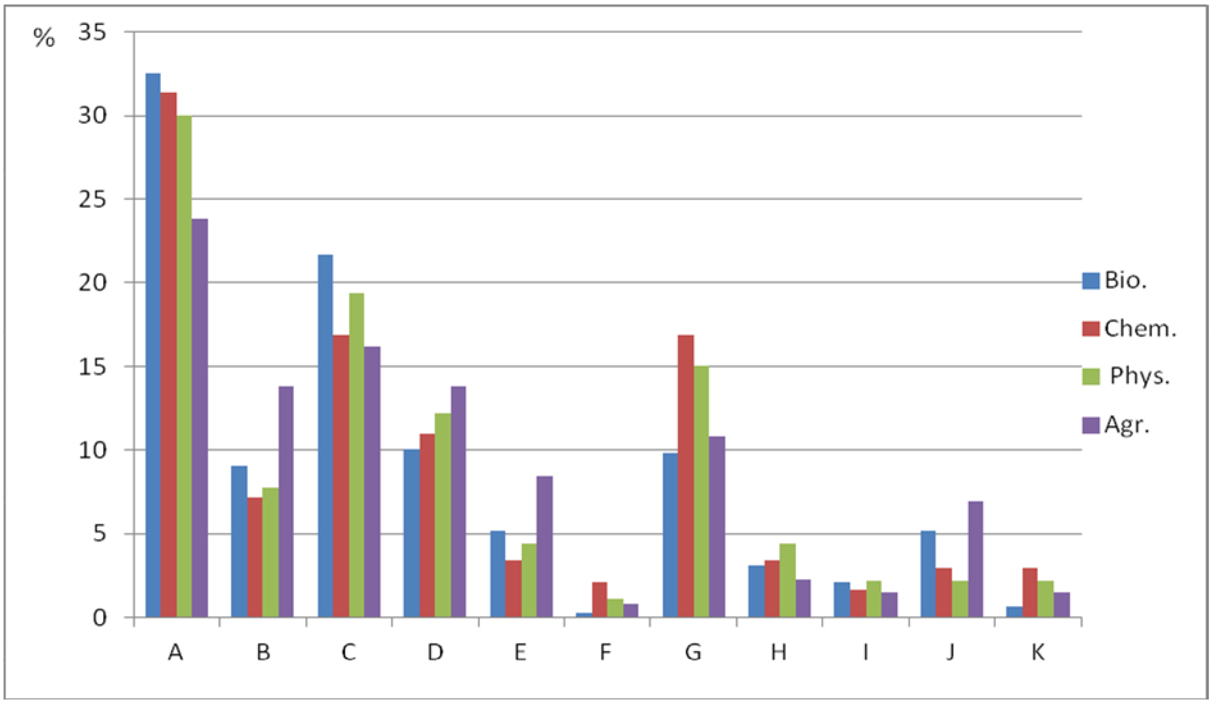

Figure 9: Students' responses about the influence of science and technology on creation or solution of social problems

From the data presented in the table 22 and in the graph above it can be seen that in all four courses the option A was the most chosen, and it is categorized Has Merit.

The second most chosen option was C in all four courses. This option is considered ***Realistic*** view by the panel of judges.

The third most chosen option was D in biology and agriculture courses, and was G for chemistry and physics courses. Both options are categorized as Has Merit.

This question has two parts: one positive that advocates that there should be trade-offs, and the other negative advocating the opposite. By preferring the option A it can be inferred that in all four courses students believe that there are trade-offs between the benefits of science and technology and its negative effects. The reason advocated is because behind every new development there is at least one negative result. This is partly true, but the appropriate view is the option C that asserts that the positive and negative impacts depend on a person's viewpoint.

It is interesting to note that in this VOSTS item, the option G, advocating that there are not always trade-offs between benefits and negative effects, had a relatively high number, The reason posed on the statement is because *negative effects can be minimized through careful planning and testing.* This position is contradictory to the option A, and show how confuse students are to make choice on this matter.

For Mozambique, with very low or insignificant industrial development, students have no personal experience or live examples from the country about either positive or negative impacts of science and technology. Despite that, it can be speculated that students' position was influenced by media or what they learned at school in science classes.

In summary, students' opinions about whether there should hake trade-offs between the benefits and negative effects of science and technology are not in line with what is commonly accepted in scientific community. Their believe is that behind every new development there is at least one negative result. This is partly true, but the realistic view is the one that advocates that ***the positive and negative impacts of science and technology depend on a person's viewpoint.***

5.2.6. Students' Opinions about the Role of Science and Technology to Solve Social Problems

This section gives students' opinions about the role science and technology to solve social problems of a country. The six statements (A to F) presented in the table below, excluding the last three options, encompass three broad ideas: there is a great role of science and technology, there is no role at all and the idea that it is hard to see how science and technology can help solving social problems.

Q6: 40412: Science and technology offer a great deal of help in resolving such social problems as poverty, crime and unemployment. **Your position, basically:** (Please read from A to I, and then choose one.)	% per Course				Category
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
A. Science and technology can certainly help to resolve these problems. The problems could use new ideas from science and new inventions from technology.	29.0	26.7	30.0	20.0	HM
B. Science and technology can help resolve some social problems but not others.	9.4	6.4	15.6	18.5	HM
C. Science and technology solve many social problems, but science and technology also **cause** many of these problems.	27.3	33.1	22.8	25.4	HM
D. It's not a question of science and technology helping, but rather it's a question of **people** using science and technology wisely.	16.1	14.0	13.3	16.2	**R**
E. It's hard to see how science and technology could help very much in resolving these social problems. Social problems concern human nature; these problems have little to do with science and technology.	10.5	13.6	11.1	12.3	N
F. Science and technology only make social problems worse, It's the price we pay for advances in science and technology.	1.7	1.7	1.7	3.1	N
G. I don't understand.	2.8	0.8	0.6	0.8	P
H. I don't know enough about this subject to make a choice.	1.7	2.1	3.3	3.1	P
I. None of these choices fits my basic viewpoint.	1.4	1.3	1.7	0.8	P

Table 18: Students' responses about the role of science and technology to solve social problems

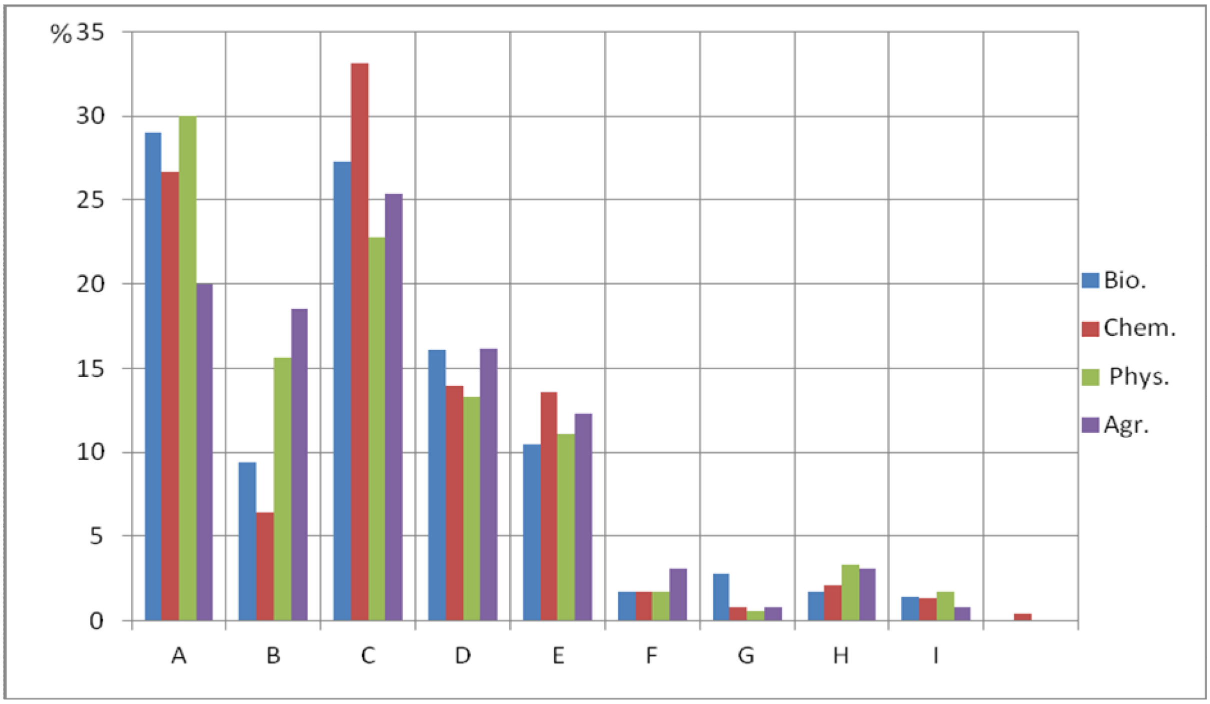

Figure 10: Students' responses about the role of science and technology to solve social problems

From the data shown in the table 23 and in the graph above it can be seen that the response were evenly distributed in the four courses. The first choice was the option A in biology and physics and it was C for chemistry and agriculture. Both options are categorized Has Merit.

The second most chosen option was A in chemistry and agriculture, while the option C was the second most preferred by biology and physics course. As referred above, both options are considered Has Merit.

The option D was the third most chosen in biology and chemistry, and it is categorized as ***Realistic*** view, while the third most chosen option for physics and agriculture was B and it is categorized Has Merit.

From students' answers pattern it can be inferred that the overwhelming majority of students see science and technology playing great role to solve social problems. The main reasons advanced are the use of new ideas and new inventions (option A), limited scope of social problems (option B), and beside solving social problems science and technology is also viewed as cause of some of these problems (option C). All these options are partly true, but the most appropriate view would be the one that do not rely solely on the science and technology, but a great role should be given to the people and how they use what they have at their disposal on science and technology to solve social problems.

It can speculated that for Mozambican context the results shown in this VOSTS are in accordance with the expectations of the majority of the population of the country, facing many social problems and yet trusting that they can be solved with the advancement of science and technology of the country. The new changes in the educational system, trying to make science content more relevant and meaningful for learners, and the country middle and long term development plan put the technology as one of the top priority.

In summary, students' opinions about the role of scientists and technologists to solve social problems are based on some misconceptions, because the overwhelming majority of students see science and technology playing great role to solve social problems. The main reasons advanced are three: The first is, the use of new ideas and new inventions, the second, is limited scope of social problems that can be solved by science and technology, and the third is, beside solving social problems science and technology is also viewed as cause of some of these problems. All these three opinions are partly true, but the most appropriate view would be the one that do not rely solely ***on the science and technology, but that pose a great role to the people and how they use what they have at their disposal on science and technology to solve social problems.***

5.2.7. Students' Opinions about the Awareness of Scientists and Technologists about the Media

This section gives students' opinions about whether scientists and technologists in spite of their knowledge and training can be fooled by the media. The five statements (A to E) presented in the table below, excluding the last three options, encompass two broad positions: the first is affirmative and the second one is negative.

Q7: 40441 In spite of their knowledge and training, scientists and technologists can be fooled by what they see on TV or read in newspapers. Your position, basically: (Please read from A to H, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
Scientists and technologists CAN BE fooled by the media:					
A. because they are so open-minded and always accept new ideas.	16.8	17.8	15.6	12.3	HM
B. because their special knowledge doesn't help them detect errors in the media.	9.4	6.4	11.7	8.5	N
C. because they are only human. Like everyone, **they are influenced** by the media (except when the topic is in their field of specialization).	29.7	25.4	25.6	34.6	**R**
Scientists and technologists are NOT fooled by the media:					
D. because they know the facts. Knowledge of science tells them what is correct.	11.9	11.0	14.4	15.4	HM
E. because they are trained to look at things logically. They know the correct information or they know how to check it out.	18.5	26.3	21.7	18.5	HM
F. I don't understand.	3.5	3.4	4.4	2.3	P
G. I don't know enough about this subject to make a choice.	6.3	5.1	4.4	2.3	P
H. None of these choices fits my basic viewpoint.	3.8	4.7	2.2	4.6	P

Table 19: Students' responses about the awareness of scientists and technologists about the media

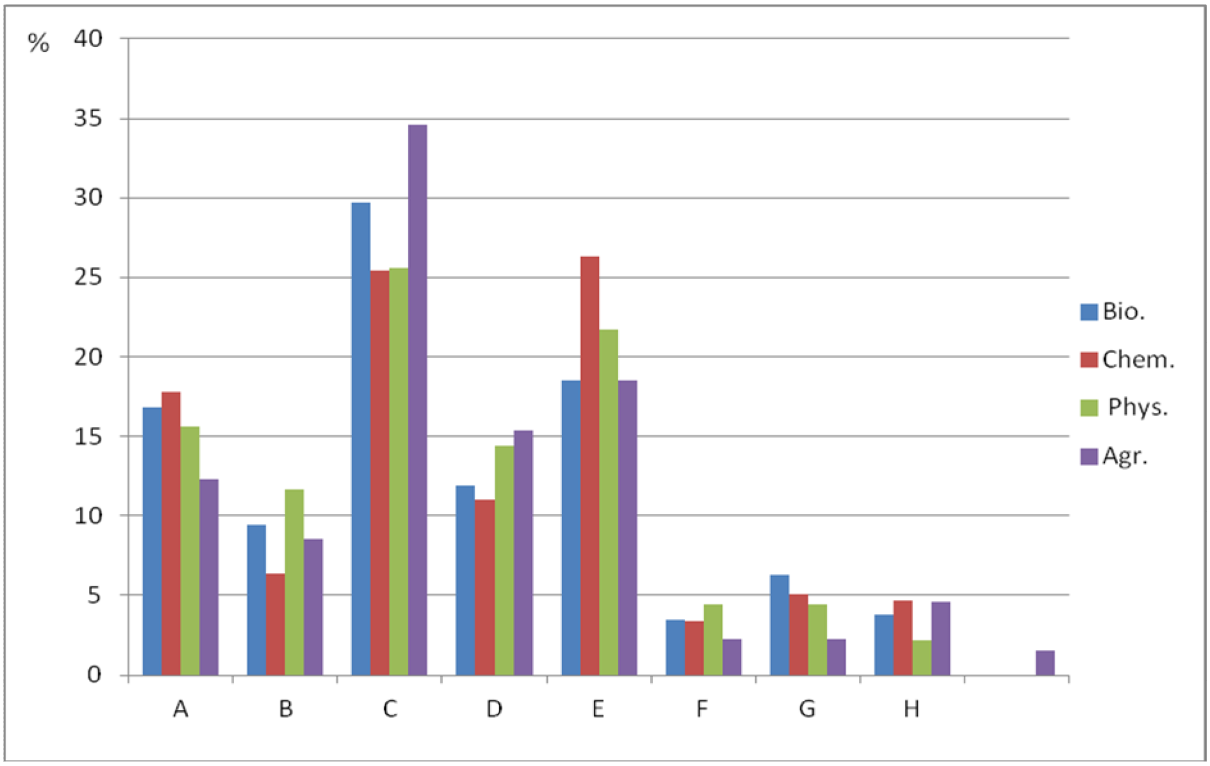

Figure 11: Students' responses about the awareness of scientists and technologists about the media

From the data presented in the table 24 and in the graph above it can be seen that the option C was the first choice in three course: biology, physics and agriculture and it is categorized as Realistic view, while for the chemistry course the first choice was the option E and it is considered Has Merit.

The second most chosen option was E for the cluster of three courses: biology, physics and agriculture, referred above Has Merit, and for chemistry course the option C was the second most chosen, and as referred above is considered as Realistic view.

The option A was the third most chosen option in the cluster of the three natural science courses: biology, chemistry and physics, and for agriculture course was the option D. Both option are categorized as Has Merit.

This VOSTS item contain two parts: the first, supports that scientists and technologists can be fooled by the media, and the second supports the opposite. By looking at students' answers it can be inferred that the options are scattered between either positions.

The most appropriate view, the option C, encompasses the idea that scientists and technologists above all are social individuals and therefore subject to all type of influence from the media. The other two most chosen option considered with some legitimate issues, the options A and D, give scientists an technologists special skills that can prevent them from being fooled by the media which is partly true.

In the Mozambican context where students are not trained and used to think critically these results are not surprising because in general students tend to believe in everything that is presented by the media. Furthermore, is not yet well established the class of scientists and technologists due to relatively not developed economy, thus students have difficult to grasp the characteristics of their job and the importance for the society.

In summary, students' opinions about whether scientists and technologists in spite of their knowledge and training can be fooled by the media is considered realistic, more in accordance to what is accepted in scientific community about the issue. The majority of the students believe that given their special skills it will prevent them from being fooled by the media. This assertion is partly true, but ***neglects the fact that above all scientists and technologists are social individuals and as such subject to all type of influence social influence, including being fooled by the media***.

5.2.8. Students' Opinions about whether More Technology Improve the Standard of Living

This section gives students' opinions about whether more science and technology will improve the standard of living of Mozambicans. The six statements (A to F) presented in the table below, excluding the last three options encompass two broad ideas: one is affirmative, for many reasons and the other is negative because of human irresponsibility.

Q 8: 40531. More technology will improve the standard of living for Mozambicans. **Your position, basically:** (Please read from A to I, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
A. Yes, because technology **has always** improved the standard of living, and there is no reason for it to stop now.	15.7	19.1	11.1	20.0	HM
B. Yes, because the more we know, the better we can solve our problems and take care of ourselves.	31.1	33.5	29.4	28.5	**R**
C. Yes, because technology creates jobs and prosperity. Technology helps life become easier, more efficient and more fun.	15.4	14.0	17.8	13.1	N
D. Yes, but only for those who can afford to use it. More technology will cut jobs and cause more people to fall below the poverty line.	15.7	7.6	14.4	14.6	HM
E. Yes and no. More technology would make life easier, healthier and more efficient. BUT more technology would cause more pollution, unemployment and other problems. The standard of living may improve, but the quality of life may not.	10.8	16.1	12.8	12.3	HM
F. No. We are irresponsible with the technology we have now; for example, our production of weapons and using up our natural resources.	6.3	2.5	7.8	3.8	N
G. I don't understand.	1.4	2.5	1.7	1.5	P
H. I don't know enough about this subject to make a choice.	2.1	1.3	3.3	4.6	P
I. **I.** None of these choices fits my basic viewpoint.	1.4	2.5	1.7	0.8	P

Table 20: Students' responses about whether more technology improve the standard of living

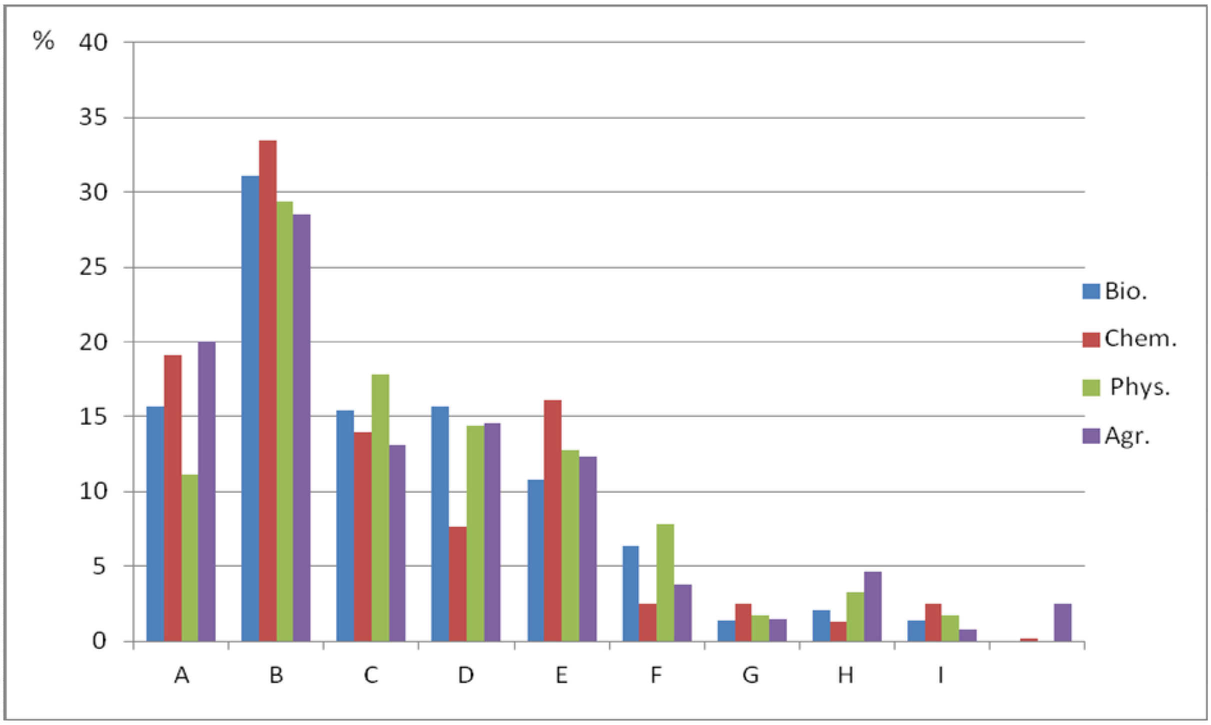

Figure 12: Students' responses about whether more technology improve the standard of living

From the results presented in the table 25 and in the graph above it can be seen that the first choice in all four course was B, and it is considered by the panel of judges as Realistic view.

The option A was the second most chosen for biology, chemistry, considered Has Merit, while for the agriculture course the second most chosen option was C, categorized as Naïve view.

The third most chosen option was C for biology course, referred above as **Naïve** view, the option D was the third choice for physics and agriculture course, while for chemistry course the third choice was the option E. Both, the options D and E are categorized as Has Merit by the panel of judges.

From students' responses pattern it can be inferred that their answers in all four courses were in accordance with the appropriate view which encompasses the idea that more technology can improve our standard of living because better knowledge enable us to better solve our problems. Other legitimate options chosen by students, options A, D and E, encompasses the historic perspective (option A), and on the negative impact on the job by creating more poverty, and finally by seeing technology as source of more environmental problems.

Taking into account that Mozambique is a developing country, there are few examples of negative impact of industrialization either to create environmental problems or job losses, students' responses is understandable by putting faith on technological development to improve our standard of living and solve our problems.
In summary, students' opinions about whether more technology will improve the standard of living for Mozambicans is realistic. Their responses encompasses the idea that more technology can improve our standard of living because better knowledge enable us to better solve our problems. Other legitimate issues raised encompasses the historic perspective that has always been like that, and the negative impact on the job by creating more poverty, and finally by seeing technology as source of more environmental problems.

5.2.9. Students' Opinions about Relationship between level of Development of Science and Technology with Military Power

This section gives students' opinions about whether there is a relationship between the level scientific and technological development with the military strength of a country. The six statements (A to F) presented in the table below, excluding the last three options, encompass three broad ideas: there is a direct dependence, there is no direct dependence and there is dependence but not only on the level of development of science and technology.

Q 9: 40611. The most powerful countries of the world have military strength because of the country's superior science and technology. Your position, basically: (Please read from A to I, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
Military strength depends a **great deal on** science and technology:					
A. Because the greater the development in science and technology, the more modern, accurate and destructive the weapons..	34.6	35.6	31.7	37.7	HM
B. Because the military usually has a strong voice in government, and the military will insist on using science and technology to build its strength.	14.3	9.7	13.3	8.5	N
C. Because the more advanced the country's science and technology, the **richer** the country. Its money can be spent on making the military stronger.	17.5	14.4	12.8	17.7	HM
D. Military strength depends not only on science and technology for powerful weapons, but also on the size of its armed forces.	8.0	10.6	9.4	6.2	N
E. Military strength depends **partly on** science and technology and partly on a government s decision to develop weapons to increase its power..	13.6	14.4	15.6	15.4	HM
F. Military strength does **not** depend on science and technology, but on the government. Some countries which are strong in science and technology have weak militaries (for example, Japan). Some countries which have a strong military are weak in science and technology (for example, China).	4.5	5.9	9.4	4.6	**R**
G. I don't understand.	0.7	0.8	1.7	0.0	P
H. I don't know enough about this subject to make a choice.	4.9	5.1	3.9	6.2	P
I. None of these choices fits my basic viewpoint	1.7	3.4	2.2	3.8	P

Table 21: Students' responses about the relationship between science and technology with military power of a country

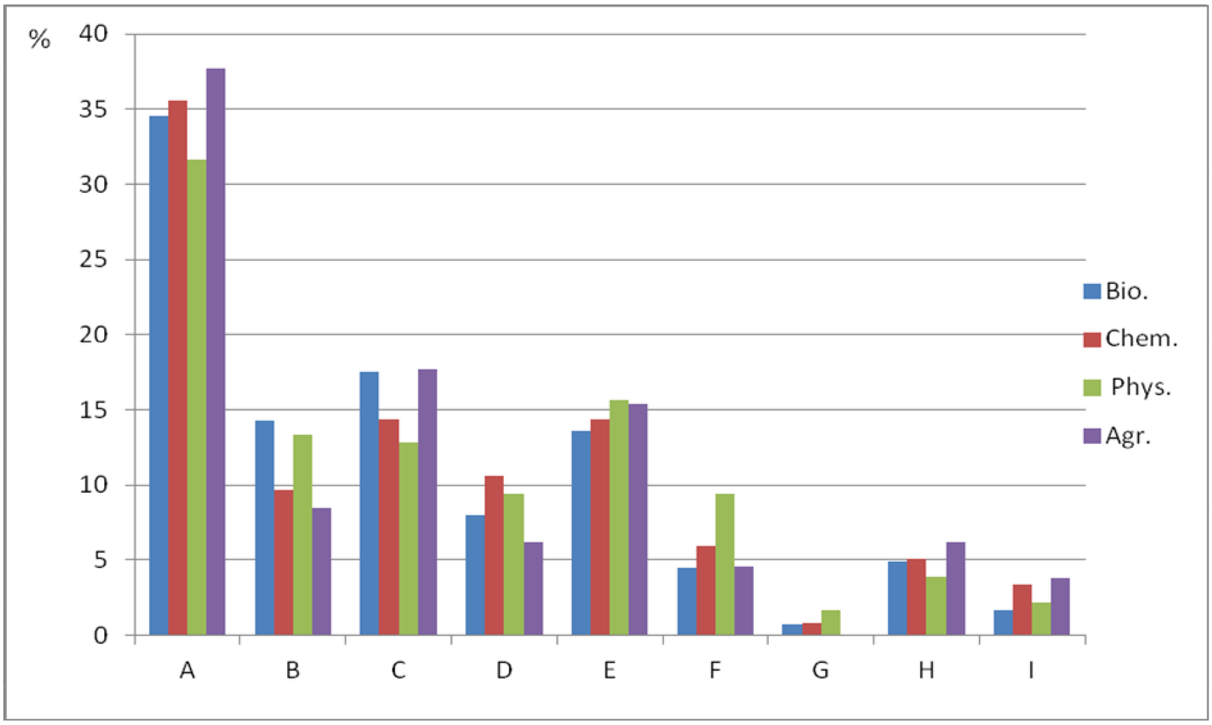

Figure 13: Students' responses about the relationship between science and technology with military power of a country.

From the data presented in table 26 and in the graph above it can be inferred that in all four courses the option A was the first choice, and according to the panel of experts this is categorized as **Naïve** view.

The second most chosen option was C for a cluster of three courses: biology, chemistry and agriculture, and it was the option E for the physics course. Both options are categorized as ***Has Merit***.

The third most chosen option was B for biology and physics course, and for chemistry course was the option D. Both options B and D are categorized as Naïve view. For the agriculture course the third most chosen option was E, and as it was referred above it is categorized as Has Merit.

This question can be divided in three parts: the first, assumes that the development of science and technology has direct impact on the military power of a country - options A, B, and C. The second, is more neutral, put the development of science and technology associated with other aspects - options D and E; and the third part advocates that there is no direct dependence between the development of science and technology and the military power of a country - option F.

From students' responses it can be inferred that in overall the two most chosen options in all four courses, A, B, and C options, they believe that the military strength of a country depend on the development of science and technology. Their positions are based on linear and direct impact of science and technology development to military power - options A and C; and because the military have the power to make their voice heard and use the advancement of science and technology - option B. These options convey some of legitimate issues about the relationship between the development of science and technology of a country and its military power. The most appropriate view though would be the option D, that places emphasis not only on the development of science and technology, but also on the size of its armed force.

In summary, students' opinions about the relationship between the military strength of a country and its advancement in science and technology have many misconceptions. The majority of students' responses are based on the assertion that the military strength of a country depends directly on the level of development of science and technology of a country. Their positions are based on linear impact of science and technology development to military power, and because the military will make their voice heard and make use of the advancement of science and technology of a country. Although these positions have some legitimate issues the most appropriate view is considered the one that ***places emphasis not only on the development of science and technology, but also on the size of its armed force***.

5.2.10. Students' Opinions about the Influence of Science and Technology and Contribution to Social Thinking

This section gives students' opinions about whether science and technology give us news words and ideas due to its influence to our everyday thinking. The six statements (A to F) presented in the table below, excluding the last three options, encompass two broad ideas: the first, is affirmative advocating that science and technology have great influence on our words and ideas and the second is opposite.

Q 10: 40711 Science and technology influence our everyday thinking because science and technology give us new words and ideas. **Your position, basically:** (Please read from A to I, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
A. Yes, because the more you **learn about** science and technology, the more your vocabulary increases, and thus the more information you can apply to everyday problems.	29.0	30.9	32.2	33.1	HM
B. Yes, because we use the **products** of science and technology (for example, computers, microwaves, health care). New products add new words to our vocabulary and change the way we think about everyday things.	18.9	13.6	19.4	20.0	HM
C. Science and technology influence our everyday **thinking** BUT the influence is mostly from new ideas, inventions and techniques which broaden our thinking.	29.4	7.5	25.0	23.1	HM
Science and technology are the most powerful influences on our everyday lives, ***not*** *because of words and ideas:*					
D. But because almost everything we do, and everything around us, has in some way been researched by science and technology.	8.4	15.3	9.4	10.0	**R**
E. But because science and technology have changed the way we live.	1.4	2.1	3.3	6.9	HM
F. No, because our everyday thinking is mostly influenced by non-scientific things. Science and technology influence only a few of our ideas.	2.4	3.4	2.8	5.4	G
G. I don't understand.	4.9	2.5	4.4	0.8	P
H. I don't know enough about this subject to make a choice.	3.8	2.5	2.2	0.0	P
I. None of these choices fits my basic viewpoint.	1.4	2.1	1.1	0.8	P

Table 22: Students' responses about the influence of science and technology and contribution to social thinking

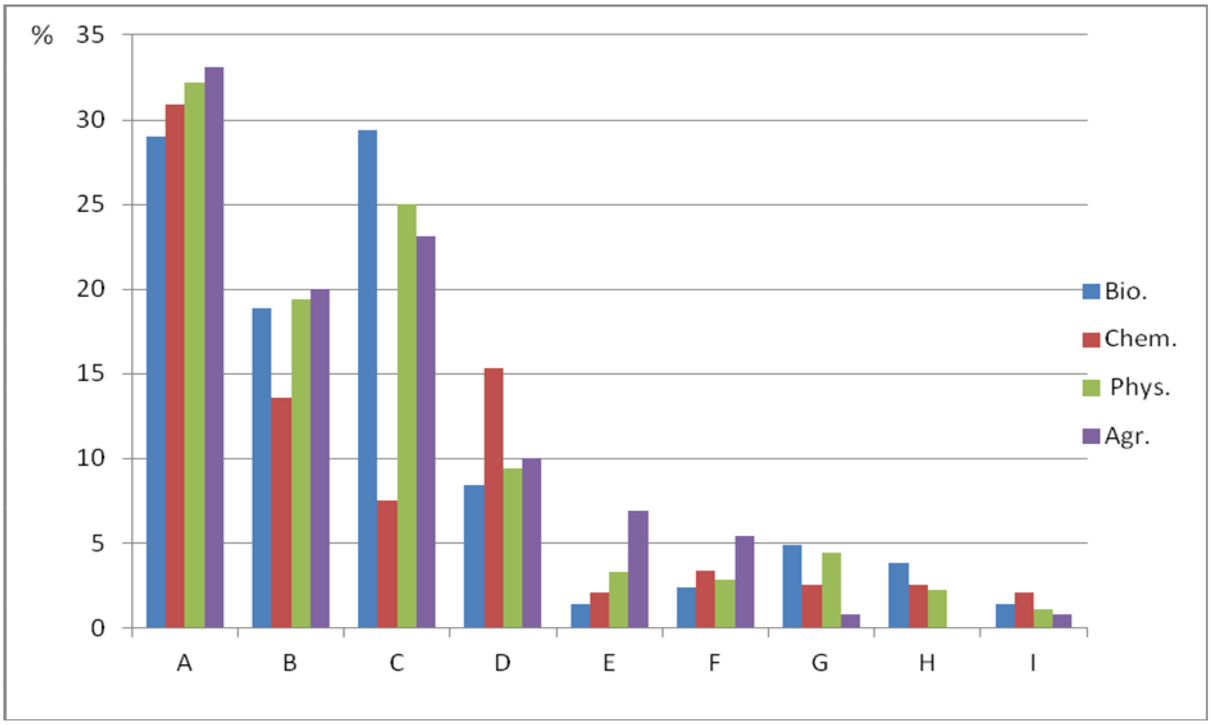

Figure 14: Students' responses about the influence of science and technology and contribution to social thinking

From the table 27 and in the graph above it can be seen that the option A was the first choice in a cluster of three courses: chemistry, physics and agriculture, while for the biology course was the option C. Both options are categorized as Has Merit.

The second most chosen option was A for the biology course, it was C for physics and agriculture, and was D for the chemistry course. The option D is considered Realistic view, while the other two options, A and C, are considered Has Merit.

The option B was the third most chosen in all four courses and it is categorized as Has Merit.

This VOSTS items has two parts: the first, a positive statement that science and technology influence our everyday thinking because give us new words and ideas, and it encompasses the options A, B and C. The second part, a negative statement, encompassing the options D, E and F.

From students' answers it can be inferred that in all courses, with exception of chemistry students' believe that everyday thinking is influenced by new words from science and technology. This perception is partly correct, but the most appropriate is the one that consider that everything surrounding us has been in some way researched by science and technology.

It is important to note that students from chemistry course the second most chosen option was D, and its encompasses the idea that everything around us is influenced by science. Taking into account the content of secondary school chemistry curriculum this perceptions is more or less imbedded and presented at the end of almost every didactic unity. The underlying idea that chemistry teachers try to convey is that chemistry is everywhere and everything in our lives is influenced by chemistry.

In summary, students' opinions about the Influence of science and technology and contribution to social thinking have many misconceptions. They believe that everyday thinking is influenced by new words from science and technology, and that science and technology have influenced the way we live. These opinions are partly correct, but the most appropriate assertion is the one that ***consider that everything surrounding us has been in some way researched by science and technology***. This is an open minded opinion about the nature of science and is more in accordance with what is expected by students when pursuing science curriculum in school.

5.2.11. Students' Opinions about the Science Classes vs Media about Accuracy of Really Science

This section gives students' opinions about who gives more accurate picture of really science the media or science classes The seven statements (A to G) presented in the table below, excluding the last three options, encompass three broad ideas: there first is that the media gives more that the science classes, the second is that the science classes give more than the media and the third idea is that both, give accurate picture of really science based on their terms of reference.

Q11: 50313 The mass media in general (TV, newspapers, magazines, movies, etc.) give a *more* accurate picture of what science really is in Mozambique, compared to the picture offered by science classes. Your position, basically: (Please read from A to K, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
The mass media give a more accurate picture:					
A. Because the media show all sides of science. in science classes, you may not get the whole picture because of the teacher's bias.	11.9	9.7	10.6	6.9	N
B. Because the media are more up-to-date in their coverage.	9.4	8.9	10.6	19.2	N
C. Because the media use pictures. Pictures usually describe events more clearly than words do.	18.5	14.8	18.3	16.9	HM
D. because the media concentrate more on new developments which show how science is put to use in the real world. Science classes **only** give you notes, problems, laws and theories that do not apply to everyday life.	19.9	21.6	19.4	17.7	N
E. **Both** the media and science classes give accurate pictures of science. The media concentrate more on new developments which show how science is put to use in the real world. **Science classes concentrate more** on the underlying principles that help explain what the media are reporting on.	18.9	18.6	15.6	24.6	**R**
F. **Neither** the media nor science classes give accurate pictures of science. The media exaggerate, distort and oversimplify. Science classes only give you notes, problems and details that do not apply to everyday life. Science classes give a **more** accurate picture because classes give the facts, the explanations, and the chances to do it yourself through studying science step by step (that is, you learn how science really happens).	5.9	6.8	8.9	3.1	HM
The media:					
G. only give specific or simple examples, though they may be interesting to look at. These examples produce a narrow view of science.	5.2	6.8	3.9	1.5	HM
H. basically give people what they want to see: controversy, opinions, exaggerations and simple explanations.	0.0	3.4	4.4	1.5	HM
I. I don't understand.	3.1	3.0	3.3	2.3	P
J. I don't know enough about this subject to make a choice.	4.5	2.5	3.3	4.6	P
K. **K.** None of these choices fits my basic viewpoint.	2.4	3.8	1.7	1.2	P

Table 23: Students' responses about science classes vs media about accuracy of real science

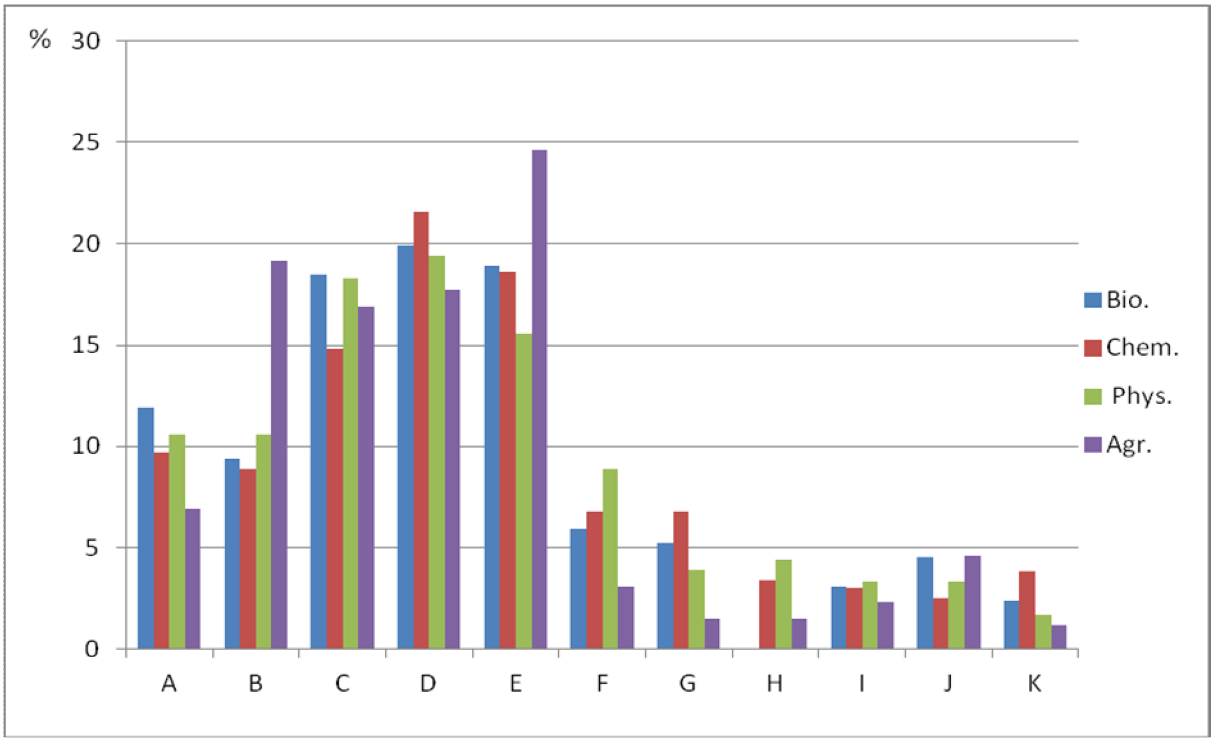

Figure 15: Students' responses about science classes vs media about accuracy of real science

From the data presented in the table 28 and in the graph above it can be seen that D was the first option in a cluster of three natural science courses: biology, chemistry and physics, and it is considered Naïve view. The most chosen option for agriculture course is E, and it is the Realistic view.

The second most chosen option was E for biology and chemistry course, and as was referred above is considered Realistic view. For the physics course the second most chosen option was C, categorized as Has Merit, while for the agriculture course the second most chosen was B, categorized as Naïve.

The third most chosen option was C for biology and chemistry course, and as referred above is considered Has Merit. The option E was the third choice physics, and as referred above it is the Realistic view, while for the agriculture course the option D was the third most chosen and it categorized as Naïve view.

This VOSTS item is divided into parts: The first, advocated the idea that the media gives more accurate picture of science than science classes, encompassing the options A, B, C, D, E, and F, and the second part advocates the opposite and encompasses the options G and H. From students' answer pattern it can be inferred that the overwhelming majority of students are more inclined to the first option. The middle term of the first part, considered the most appropriate view, is the one that consider shared responsibility of both media and science classes on presenting accurate really science.

It can be speculated that from the Mozambican perspective the answer pattern shown by students reflects the discontent with science curricula in the country and rely heavily on the media for information related to science.

Similar results occurred in different countries as reported by Aikenhead (1988, p.613), where Canadians and USA students relied highly on media for STS information, and in Australia, England and Israel 16 - year - old acquired most of their environmental knowledge from the media.

In summary, students' opinions about who gives more accurate picture of what really science is the media or science classes is more or less acceptable, because most of them are either realistic or closely related to that. They are more inclined to the opinion that advocates that the media gives more accurate picture than the science classes. Although these positions have some legitimate issues the most appropriate view, is the one ***that consider shared responsibility of both media and science classes on presenting accurate really science***.

5.2.12. Students' Opinions about the Role of Scientists to Decide to Apply New Technological Development

This section gives students' opinions about whether new technology should be used depending on the explanation about why it works. The six statements (A to F) presented in the table below, excluding the last three options, encompass two broad ideas: the first is that new technology should be well explained before it is used, and the second idea is that the use of new technology does not depend on the explanation of scientists.

Q 12: 80122 When a new technology is developed (for example, a new medicine to fight cancer), it may or may not be put into practice. The decision to use a new technology depends on whether scientists have been able to explain why it works. Your position, basically: (Please read from A to I, and then choose one.)	**% per Course**				**Category**
	Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
The decision to use a new technology depends MAINLY on whether scientists have been able to explain why it works:					
A. so that they can tell what problems may arise.	18.5	19.1	18.9	13.1	N
B. so that society can decide whether or not to use it; and if so, how to use it properly and without fear.	22.0	16.1	20.0	29.2	HM
C. because a technological development has to work in theory before it will work in practice.	33.2	35.6	33.3	26.9	N
The decision to use a new technology does NOT depend on whether scientists can explain why it works:					
D. because the decision depends on how safe it is.	4.5	7.2	5.6	4.6	HM
E. because the decision depends on a number of things: how well it works, its cost, its efficiency, its usefulness to society, and its effect on employment.	10.1	11.0	10.6	9.2	R
F. because a new technology can work well without a scientist explaining why it works.	4.9	2.1	2.8	3.1	HM
G. **G.** I don't understand.	2.1	3.0	2.8	6.2	N
H. I don't know enough about this topic to make a choice.	2.8	3.0	3.3	4.6	P
I. **I.** None of these choices fits my basic viewpoint.	1.4	3.0	2.8	3.1	P
	0.3	0.0	0.0	0.0	P

Table 24: Students' responses about the decision to apply new technological development

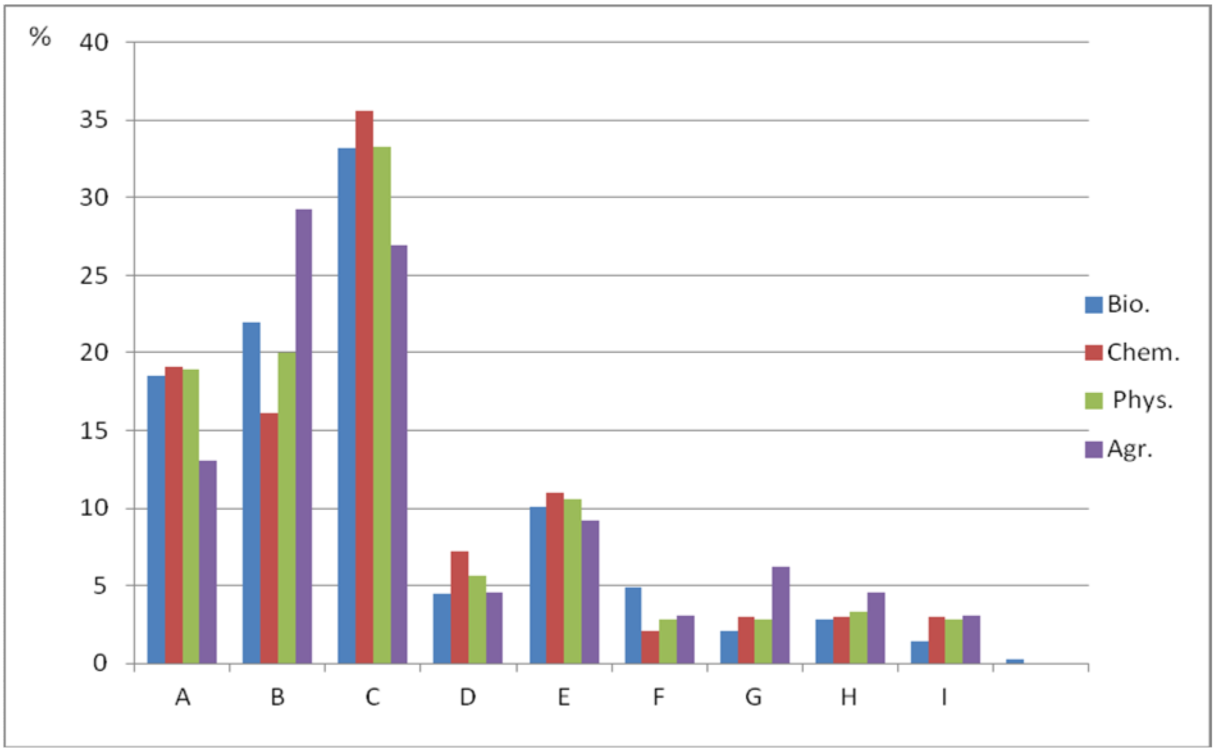

Figure 16: Students' responses about the decision to apply new technological development.

From the data presented in the table 29 and in the graph above it can be seen that the option C is the first choice in the cluster of three natural science courses: biology, chemistry and physics, and it is considered by the panel of judges as Naïve view. For the agriculture course the option B was the most chosen and it is categorized as Has Merit.

The second most chosen option for biology and physics course was B, and as referred above it is categorized as Has Merit. For Chemistry course the second most chosen option was A, while for the agriculture course the second most chosen option was C. Both options A and C are considered by the panel of judges as Naïve view.

The option A was the third most chosen option by a cluster of three courses: biology, physics and agriculture, considered Naïve view, while for chemistry course the third most chosen option was B, and as was referred above it is categorized as Has Merit.

This VOSTS item is divided into two parts: the first, advocates that the use of a new technology depends on the scientists explaining why it works, and it encompasses the options A, B and C. The second part, advocates the opposite, and encompasses the options D, E and F.

From students' answer pattern it can be inferred that the overwhelming majority of students in all four courses believe that scientists should explain a new technology developed before using it. The reasons advanced for this view are related to: preventing problem (option A); the match of intended design and the actual functionality (option C) - both options are considered not adequate. The option that consider the need of explanation of scientists about a new technology to make it being used properly (option B) has some legitimate issues. But, the most appropriate statement in this item is the one that advocates that the decision to use a new technology depends on a number of things not only by explaining why it works (Option E), and it was not among the first four choices of the students from all four courses.

For Mozambican context the answer to this VOSTS item can be speculated that students are just guessing, because there are no examples of new technologies developed in the country, and do not have a well established scientific community to lead decisions about the use of a new technology either as social society or as advisors to government institutions.

In summary, students' opinions about the decision to apply new technological development have many misconceptions. Most of their opinions converge on the believe that scientists should explain a new technology developed before using it. The reasons advanced for this view are related to: preventing problems; the match of intended design and the actual functionality, and adequate, and the need for explanation of scientists about a new technology to make it being used properly. Despite having some legitimate issues the most appropriate statement, not chosen by students, is the one that advocates that ***the decision to use a new technology depends on a number of things not only on the explaining why it works***.

5.2.13. Students' Opinions about Whether a Technological Development should be Controlled by Citizens

This section gives students' opinions about whether technological developments should be controlled by citizens. The seven statements (A to G) presented in the table below, excluding the last three options, encompass two opposite ideas: the first one advocates that the citizens should control, and the second one is that the citizens should not be involved in controlling technological developments.

Q13: 80211 Technological developments can be controlled by citizens. **Your position, basically:** (Please read from A to J, and then choose one.)		% per Course				Category
		Bio. (N=286)	**Chem. (N=236)**	**Phys. (N=165)**	**Agr. (N=145)**	
A.	Yes, because from the citizen population comes each generation of the scientists and technologists who will develop the technology. Thus citizens slowly control the advances in technology through time.	35.3	33.1	36.7	24.6	HM
B.	Yes, because technological advances are sponsored by the government. By electing the government, citizens can control what is sponsored.	20.6	17.4	18.3	29.2	HM
C.	Yes, because technology serves the needs of consumers. Technological developments will occur in areas of high demand and where profits can be made in the market place.	17.5	15.7	10.6	13.1	HM
D.	Yes, but only when it comes to putting new developments into use. Citizens cannot control the original development itself.	6.3	3.8	6.1	4.6	HM
E.	Yes, but only when citizens get together and speak out, either for or against a new development. Organized people can change just about anything.	5.6	10.2	13.9	10.0	**R**
	No, citizens are NOT involved in controlling technological developments:					
F.	because technology advances so rapidly that the average citizen is left ignorant of the development.	1.7	4.2	4.4	1.5	HM
G.	because citizens are prevented from doing so by those with the power to develop the technology.	2.1	1.3	1.1	3.1	N
H.	I don't understand.	3.5	4.7	2.8	6.2	P
I.	I don't know enough about this topic to make a choice.	4.2	4.7	3.9	4.6	P
J.	None of these choices fits my basic viewpoint.	2.8	5.1	2.2	3.1	P

Table 25: Students' responses about the control of technological development by citizens

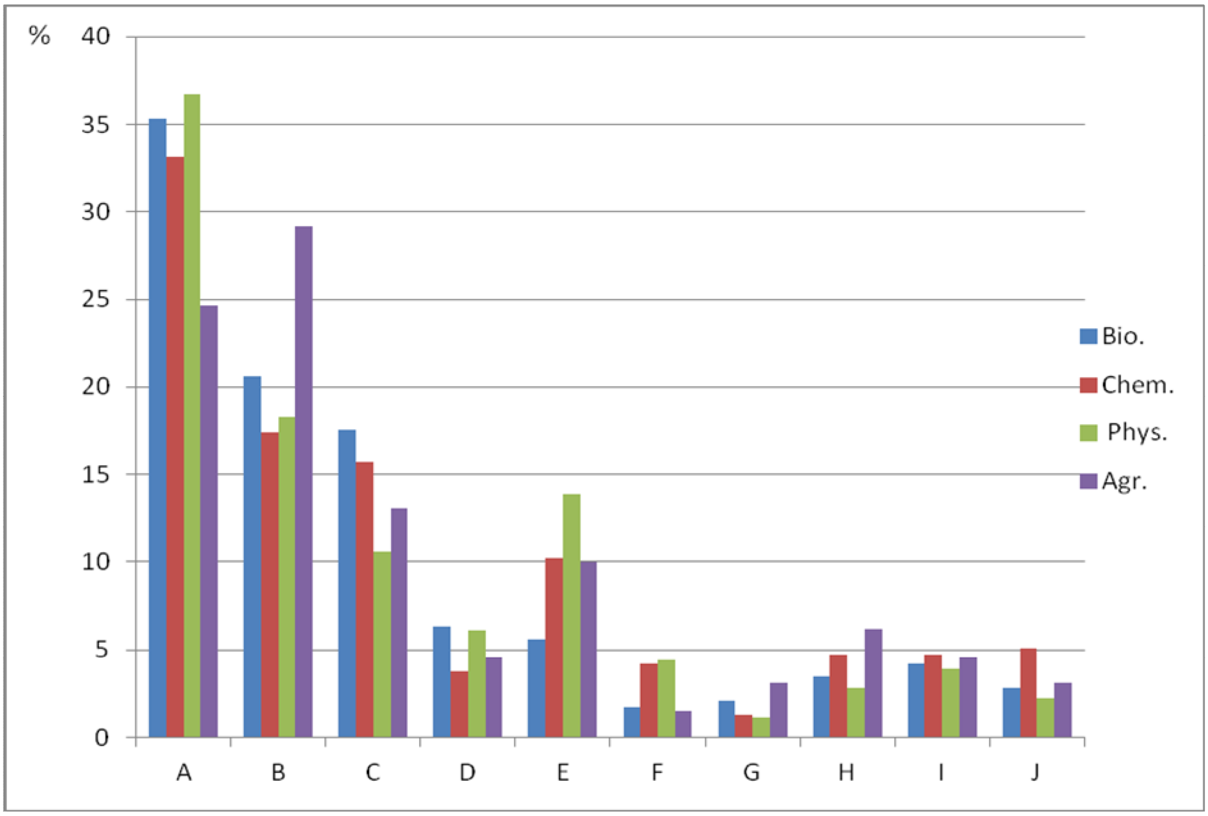

Figure 17: Students' responses about the control of technological development by citizens

From the data presented in the table 30 and in the graph above it can be seen that the option A was the first choice for a cluster of three courses of natural science: biology, chemistry and physics, while the option B was the most chosen by the agriculture courses. Both options are considered Has Merit by the panel of judges.

The second most chosen option is B, and again the cluster of the courses from natural science: biology, chemistry and physics had the same choice, and for the agriculture course the second most chosen option was A. As referred above, both options A and B are categorized Has Merit.

The option C was the third most chosen for the cluster of three courses: biology, chemistry and agriculture, and it is considered Has Merit by the panel of judges. For the physics course the third most chosen option was E, and it is considered the Realistic view.

This VOSTS item is divided into two parts: the first that advocated that technological developments can be controlled by the citizens, and the second part that advocates the opposite. From the answer patter shown it can be inferred that overwhelming majority of students from the four courses preferred the first part. Although the three most chosen options have some legitimate issues, the most appropriate view is the one that advocate the participation of citizens in organized manner and when they can speak out either for or against a new development.

Looking at the Mozambican context students' responses are more in accordance with context in which the country lives: young democratic institutions with civil society speaking out about issues that matter, including technological development produced inside or outside the country.

In summary, students' opinions about whether technological developments can be controlled by citizens have many misconceptions. They believe that technological developments can be controlled by the citizens because of a number of reasons, including: the citizens are nest for future scientists; citizens elects the government and may control its sponsorship, and because it will be depending on the market demand. Although these reasons encompass legitimate issues, ***the most appropriate view is the one that advocate the participation of citizens in organized manner and when they can speak out either for or against a new development***.

5.3. Summary of Students' Views and Beliefs in the Baseline Study

In the sub-chapter 5.2 there was a description of students' views in each of the thirteen (13) VOSTS items that comprised the questionnaire used in the baseline study, and for that purpose a descriptive statistic was used.

The table below summarizes the categorization made to students' responses to the 13 VOSTS items questionnaire, showing in which questions were the most chosen view.

Category of Answer	Number of Questions	Percentage (%)
Realistic	Q_3; Q_4; and Q_8;	23
Has Merit	Q_1; Q_5 Q_6; Q_7 Q_8; Q_{10} and Q_{13}	54
Naïve	Q_2; Q_9; and Q_{12}.	23
Passive	---------------------------------	0
Total:	***13***	***100%***

Table 31: Summary of number of questions chosen by students per category

One of the aim of the study was to identify Mozambican students' views and believes about STS issues. According to the categorization devised in this study, positive result would be if most of the responses fall into the ***Realistic*** and ***Has Merit*** categories.

The table below summarizes students' responses in each VOSTS statement question per category:

Category	VOSTS Number	Students" View or Believes about:
Realistic	Q_3: 20511	Whether Success in Science and Technology Depends on more Science in School.
	Q_4: 40217	Leading Role of Scientists and Technologists to Social Decisions.
	Q_8: 40561	Whether More Technology Improve the Standard of Living.
Has Merit	Q_1: 10111	Definition of Science
	$Q_{5:}$ 40311	The Influence of Science and Technology on Creation or Solution of Social Problems.
	Q_6: 40412	Role of Science and Technology to Solve Social Problems.
	$Q_{7:}$ 40441	Awareness of Scientists and Technologists about the Media.
	Q_{10}: 40711	Influence of Science and Technology and Contribution to Social Thinking.
	Q_{11}: 50313	Science Classes Vs Media about Accuracy of Really Science.
	Q_{13}: 80211	Whether a Technological Development should be Controlled by Citizens.
Naive	Q_2: 10211	Definition of Technology.
	Q_9: 40611	Relationship between level of Development of Science and Technology with Military Power.
	Q_{12}: 80122	The Role of Scientists to Decide to Apply New Technological Development.

Table 32: Summary of students' responses to VOSTS statements per category**.**

Based on the results of the study summarized in the table above, it can be inferred that Mozambican university students have positive view about STS issues, because in 10 (77%) of the 13 VOSTS items their responses were considered ***Realistic*** or ***Has Merit***, only 3 (23%) were considered ***Naïve***, and there was no answers classified as ***Passive***.

5.4. Correlation between Students' responses and Courses

After presenting and discussing students' responses in the sub-chapter 5.2., using the same data gathered from the administration of the 13 VOSTS items to 832 students in the survey, the next step was to see whether there was an answer pattern of the students and the each of the courses they belong to. For this purpose, inferential statistic was used, because data was explored to seek correlations and identify differences between two or more groups (Larson & Farber, 2010; Cohen & Manion, 2011).

A clear definition and purpose of inferential statistic is given by Cohen & Manion (2011, p. 606):

> *"Inferential statistic strive to make inferences and predictions based on data gathered. They may infer or predict population parameters or outcomes from simple measures. "*

In fact, in this study it is the contention to find out whether students' responses to the 13 VOSTS items selected are related to each of the four courses.

Data management and analysis were performed using SPSS 20.0 to find correlation across the courses.

Using an SPSS program (version 20.0), a chi-square test was performed to calculate the p value with the 95% confidence interval. (Larson & Farber, 2011; Cohen & Manion, 2011).

The chi-square independence test was performed because the data gathered from the survey met the two basic assumptions to run this type of test (Larson & Farber, 2010): each course forms a specific category, and each course is considered as an independent group.

The table below shows the result of *Chi-square* test after performing a statistic test using an SPSS package version 20.0 (See full test in the Appendix 7).

VOSTS Item	p value	Assessment
Q_1: 10111	0.393	Not significant
Q_2: 10211	***0.030***	***significant***
Q_3: 20511	0.607	Not significant
Q_4: 40217	0.757	Not significant
Q_5: 40311	0.633	Not significant
Q_6: 40412	0.957	Not significant
Q_7: 40441	0.138	Not significant
Q_8: 40531	0.509	Not significant
Q_9: 40611	0.306	Not significant
Q_{10}: 40711	***0.014***	***significant***
Q_{11}: 50313	0.522	Not significant
Q_{12}: 80122	0.123	Not significant
Q_{13}: 80211	0.79	Not significant

Table 33: Result of *chi-square* test of the baseline study

From the results presented in table above it can be inferred that only in two of the 13 VOSTS items, Q_2 and Q_{10}, seems to have correlation on the answer pattern with the course students belong to, because the value of $p < 0.05$, and in all other questions the value of $p > 0.05$, therefore there in no significant difference.

The two questions in which the answer pattern is related to the course are:

- Q_2 (10211): Students' opinions about definition of technology, and
- Q_{10} (40711): Students' opinions about the influence of science and technology and its influence to social thinking.

Based on that it can be concluded that students' answer pattern to the 13 VOSTS items used in the survey is not related to the course, except in the two questions above presented. This means that the students hold almost the same views and believes about STS issues irrespective of the course they were enrolled. In practice it means that there are no specific views or beliefs hold by students that can be attributed to students to the course that they are enrolled - biology, chemistry, physics and agriculture.

Chapter VI: RESULTS AND DISCUSSION OF DATA FROM THE INTERVENTION

Having presented and discussed the data from the survey in the ten branches of the Pedagogical University, what gives a baseline situation of the country about STS issues, this chapter proceed with the presentation and discussion of data from other instruments.

The aim of this chapter is to present and discuss the data gathered from the intervention. It takes into consideration the selection criteria of the VOSTS items presented in the previous chapter, as well as the scoring scheme to assess students' responses, equally presented in the previous chapter.

The chapter presents and discusses the data gathered from twelve (12) weeks of intervention, and assess students' responses to the thirteen (13) VOSTS items administered in pre and post-intervention.

6.1. Outline of the Intervention Schedule

The intervention was made in two tiers: the first in 2012 and the second in 2013. Both tiers were applied in Manica branch using as the target population the second year chemistry students, teachers to be.

The figure below outlines the intervention schedule, in four steps designed: .

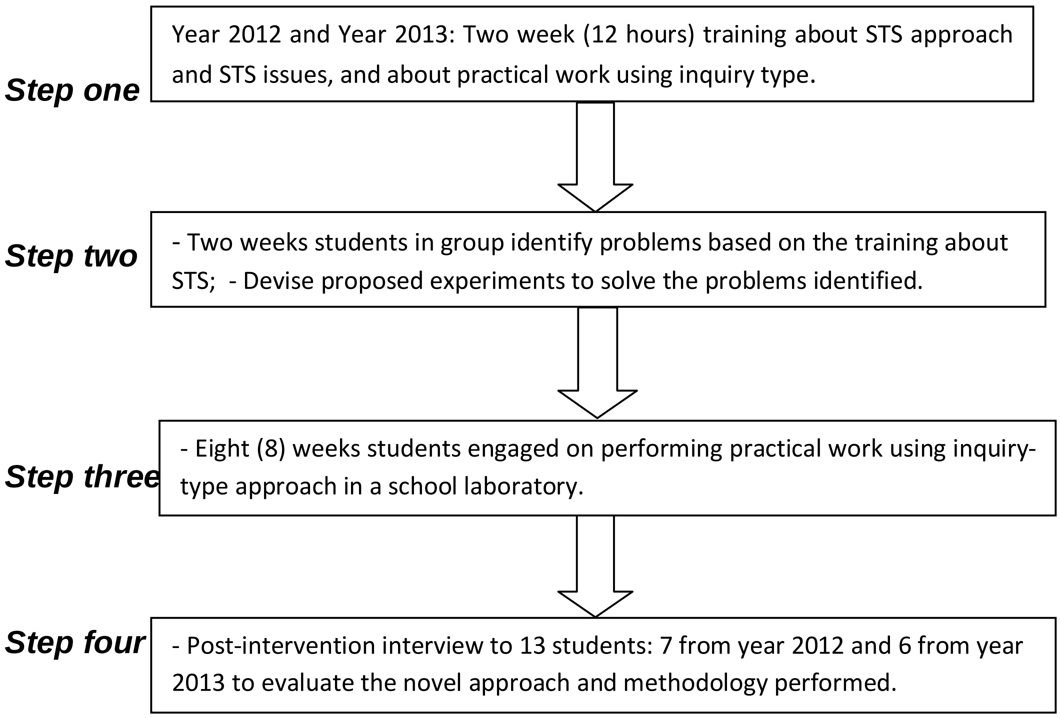

Figure 18: Outline of the intervention schedule and procedure

The whole intervention in each tier (year 2012 and year 2013) took twelve (12) weeks and was comprised of the following activities: (a). Training students about the STS approach and STS issues, and about inquiry type practical work, because it was a novel approach that uses methodology which students had never heard of and had never used before. (b). The actual practical work in two sub-stages: identifying problems and performing practical work. (c). Post-intervention interview to evaluate how the novel approach and methodology performed.

6.2. Activities Prior to the Intervention

Before starting the intervention process there was a need to train the students involved in the process. This process was conducted in two (2) weeks, three days per week (Monday-Wednesday-Friday) and on each day the sessions took 120 minutes. The first week focused on the STS approach and STS issues, and the second week was about the practical work and science process skills.

The two main reasons for the training are:

1. Almost all students who participated in the intervention had never heard about STS approach or STS issues. Therefore, there was a need to give basic information about this novel approach of teaching in Mozambique, and how it is different to traditional methods of teaching and learning which students are used to.

2. Although students are used to do practical work in a conventional and school laboratory, they never performed practical work an inquiry type and open-ended approach in. Therefore, there was a need to train students about the role of students and main features of this type of approach to practical work compared with the more traditional type of practical work to which students were used to.

The content of the training was designed to be short, precise and informative in a such a way that the students could use the knowledge and abilities gained in the actual intervention process.

6.2.1. Seminar about STS Issues and STS Approach

The training of the students about STS aimed to introduce students to this approach and methodology. The concept of STS was new to the majority of the students as well as its meaning and where could it fit within the research areas of science education.

Below it is presented the outline of the issues treated in the seminar, and the full content can be seen in the ***appendix 8.***

1. STS as one of the main researched issues in science education.

2. Definition of STS approach, and comparison with traditional methods.

3. Main features of STS approach - teachers' and students' role.

4. Definition of an STS issue and how can be identified and seek for solution.

By covering these issues it was believed that students would be equipped with basic knowledge to start using this approach and perform practical work as a means to solve identified STS problems.

Based on the students' reaction during the seminar, it is possible to draw the following conclusions:

- The approach was completely new to students and raised issues that they never thought about in science teaching and learning. In the post-intervention interview all the 14 students acknowledge that they had never heard about this approach.
- They felt insecure to pursuit this approach despite recognizing its importance to science teaching and learning.
- There was disbelieve that this approach can be applicable to the Mozambican educational context which is characterized with: crowded classroom; unqualified teachers with low motivation and a lack of laboratories, libraries and other basic teaching materials.

Despite that, students accepted the compromise to be involved in this new approach with the belief that they can succeed.

6.2.2. Seminar about Types of Practical Work and Science Integrated Process Skill

There was a need to introduce students to an inquiry-based approach of practical work, because it is the underlying methodology to perform experiments. Below it the outline of the seminars presented, the full content is presented in the ***appendix 9***.

1. importance of practical work in science teaching.

2. Types of practical work - characterization of each type.

3. Main features of inquiry type of practical work - teachers' and students' role.

4. Science Process Skills - basic and integrated science process skills.

With these topics it is believed that students would be able to perform practical work using new approach, completely different from the way they used to do at secondary school and in first and second year at university.

From the seminar it was possible to depict the following issues:

- The open-ended approach inquiry type of practical work was something they had heard about, but never thought that it is possible to apply in Mozambique.
- There was a disbelieve that the approach advocated would work in Mozambican context with the type of learners and the long standing style of teaching and learning science in Mozambique.

Despite the above presented issues, students declared themselves to be taken out of their comfort zone and engage with new approach with unknown outcome for them. They were particularly impressed with simple and integrated science process skills for being almost present in all practical work, which they had not yet recognized as having already used them.

6.3. Identification of STS Issues

After the training on STS approach and STS methods different groups were formed with a maximum of 6 and a minimum of 4 members. The groups were formed according to their convenience of the students (local of residence and easy to meet outside the university).

In a whole class session the groups were assigned with two complementary tasks:

1. Identifying relevant or meaningful problems affecting their communities. For each problem identified propose possible solutions.
2. Go to the institutions which deal with the problems identified, confirm whether they are real and find out if they are among their priorities

Different credentials were issued for students to interview and check documents of different public institutions related to the problems identified. Students were instructed to send only one or two members of the group to each institution and the result should be reported to the group and collectively take decisions about the way forward with the problem.

This process was supposed to last a week and was explicitly recommended that each group should not have more than three problems to solve by mean of practical work, using inquiry type and open ended approach.

As a result of the process in the first tier, year 2012, different groups identified 82 problems, and in the second tier 75 problems were identified. By looking at the problems posed 7 different categories were devised.

The table below sets out the categories and types of problems posed by students gathered in groups.

Category and Problems Identified	**N = 82**	**%**
1. Environmental Issues: • Waste disposal (and lack of waste disposal management) in Chimoio City; • Lack of waste disposal recycling; • Lack of waste disposal reuse; • Management of animal and human excrements; • Uncontrolled burning causes ill-management of chemical substances; • Non – use of organic manure; • Ill- management of used plastics; • Lack of shadows in some bus stop ; • Poor management of solid wastes and lack of recycling; • Erosion of soil due to construction; • Recycling of the laboratorial residues; • Sounding pollution in Chimoio city; • Environmental pollution in Chimoio city; • Isn't the use of plastic in managing foods creating a negative effect?	36	44
2. Social Issues: • Increase in alcohol consumption in Chimoio city; • Increase in the high birth rate; specially among young people; • How to combat to the alcohol consumption to reduce the dependence among teenagers; • Improvement of the ways of access to reduce accidents; • Improvement of machines (electromagnetic tools that detect diseases of users before diagnostic); • Excessive consumption of tobacco (and drugs); • Hazardous houses in Chimoio city; • Poor diet of peasants in Manica province;	15	18
3. Health and sanitation: • Inter-domiciliary Pulverization to eliminate the problem of flea (*Tunga Penetras)* in Chimoio city; • The use of chalk in schools creates human health problems; • Proximity of latrines and fresh Aren't the chemical products used in the purification of water consumed in Machaze district creating collateral effects? • Consumption of the unsafe water (contaminated); • Increase of the number of people with mental issues Can the chicken consumption create some damages in the human health? How? And how can we avoid it? • Fly causing the fruit diseases; • Sale of products outdated in various markets in Chimoio city;	10	12

4. Agriculture, Animal Farming and Food Processing: • Lack of agro-processing industry to use the agricultural surplus (i.e: fruits and vegetables); • Lack of insecticides; • High death tool of domestic animals (Cats, dogs, cattle and goats); • Use of chemical fertilizers in agriculture;	9	11
5. Educational Problems: • Low pass rate and creation of nucleus by Universities to mitigate the situation; • Use of inadequate material in laboratory; • Proliferation of Tertiary institutions. • Lack of school laboratories; • Lack of desks in schools while the province possess a potential of timber;	5	6
6. City Management: • Construction of small bridges in Chimoio city to replace those built by the eucalyptus stems; • Construction of more markets in Chimoio city;	4	5
7. Energy:. • Production of renewable energy, using low cost local materials (gas – cow excrement); • Non- use of bio-fuel ; • destruction of biomass to produce charcoal in various parts of Manica province;	3	4

Table 26: Problems proposed by students in the year 2012.

Category and Problems Identified	N = 75	%
1. Social Issues: • Criminal issues (domestic violence; kidnapping; child labor use and gun assault) • Corruption; • Lack of technicians to exploit mineral resources; • Prostitution and sexual harassment; • Lack of security in the suburbs; • inequalities of rights in public sector; • Lack of attention to small need of the population.	24	32
2. Health and sanitation: • Lack of drinking water; • Abusive or excessive consumption of alcohol;; • young or teenage pregnancy; • High rate of sexual transmitted diseases including HIV/AIDS; • High rate of child mortality; • High rate of blood pressure; • Bad treatment of patients in hospitals; • Poor personal hygiene; • Poor sanitation conditions and management; • Poor or inadequate sanitary network	15	20
3. Environmental problems: • Waste disposal and management; • Uncontrolled bushfire; • Open door defecation ; • Soil erosion, • Pollution of river and sound pollution;	14	19
4. Educational Problems: • Lack school desks, • Lack of laboratories; • Lack of technical schools and private universities; • Low pass rate; • Crowded classroom; • Teenage attending night shift school.	8	11
5. City Management: • Lack or bad management of markets, • Lack or bad system to collect garbage; • Bad location of markets (near school or hospitals); • Poor housing conditions in majority of population.	8	11
6. Agriculture: • Excessive use of pesticides and fertilizers; • Lack of food processing industry.	3	4
7. STS Issues: • Lack of perception or understanding of science by the society; • people do not know the impact of science in society; • Need to motivate and promote scientific knowledge.	3	4

Table 35: Problems proposed by students in the year 2013

In the first tier in the year 2012, from the list of the 82 problems identified by students in groups, it can be seen that the top three are related to: (1). environment issues, (2). social problems, and (3). health and sanitation, while in the second tier, from the list of the 75 problems identified by students in their groups, it can be seen that the top three are related to: (1). social problems, (2). health and sanitation, and (3). environment issues.

Below ,the combined categories of problems posed by students in year 2012 and year 2013 and their frequencies.

Category of Problem	**% (N = 157)**
1. Environmental issues	32
2. Social issues	25
3. Health and sanitation	16
4. Educational problems	8
5. Agriculture, animal farm and food processing	7
6. City management	7
7. Energy	3
8. STS issues	2

Table 36: Summary of problems proposed by students

From the data presented in the table 34 above that combines the categories of problems posed in year 2012 and 2013, it can be inferred that the top three problems identified by students are: (1). environmental issues with 32%, (2). social issues with 25%, and (3). health and sanitation with 16%.

A critical analysis to the problems posed by students in both years it can be inferred that most of them do not meet the requisites of STS issues as proposed by Yager (1993), and the majority of them would be difficult to solve by means of practical work as was suggested and proposed in this study.

In face of this problem, students were required to get rid of most of the problems identified that could not be solved by means of practical work. For the short list of the problems selected they should do a literature research to devise laboratory activities to find solutions for them.

6.4. The Experiments Proposed by Students

Based on the list of the problems identified that could be solved doing practical work, and using the result of literature review and interview to the institutions related to the problems posed the actual intervention started.

The schedule presented in the diagram below outlines what was intended by STS approach of teaching by doing practical work, using inquiry type and open ended approach:

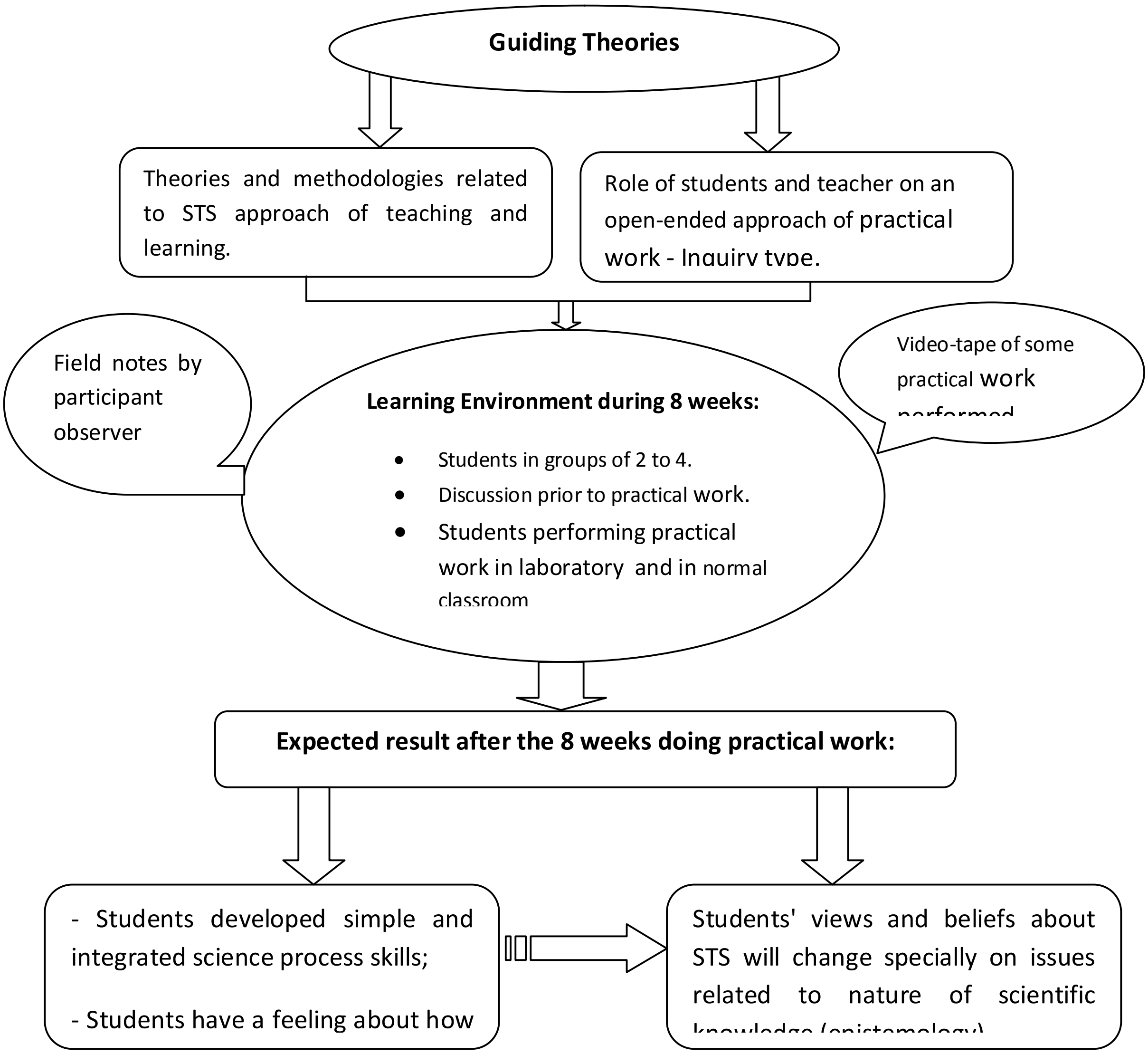

Figure 19: Outline of design of the intervention process.

After identifying the problems that they considered STS issues, students were asked to do a literature and internet research to propose preliminary solutions for them. After that they were requested to focus their attention only on problems that could be solved by means of practical work.

Despite being warned that most of the identified problems were not STS issues, according tom the features of STS issues learned in the seminar, most of the problems and experiments proposed were not applicable and most of them were mainly related to chemistry.

The list of problems that could be solved by doing laboratory activities dropped dramatically, and in the end only thirty (30) experiments in nine categories in both years could be considered to meet the requirements defined as an STS issue that can be solved by mean of experiments.

The table below summarizes the experiments designed in each category:

Order	**Experiment Related to:**	**Nº of Experiments**
1	Water treatment for consumption and other purposes.	5
2	Alcohol: determination of content of alcohol in homemade and marketed alcoholic drinks.	2
3	Tobacco: determination of nicotine	2
4	Plastics: consequences of massive use to the health	2
5	Soil: determination of fertility and fight to harmful microorganisms (*Tunga Penetrans).*	3
6	Environmental issues: waste management; production of natural pesticides, and treatment for pollution; deforestation;	6
7	Agriculture and food processing: dairy products; processing of some goods; food conservation, and determination of energetic content.	6
8	Social issues: how to prevent pregnancies of teenagers.	1
9	Health problems: identification of active principles in plants used to cure diseases; production of alternative medicines;	3
Total:		**30**

Table 37: Summary of experiments proposed by students per category

From the table above it can be seen that the most proposed experiments are related to water, environmental issues and agriculture and food processing. These are context-based issues and reflects the reality faced by the majority of Mozambicans in general, and in Chimoio city where the study took place.

From the overall descriptions of the experiments selected it can easily be seen that some of them you cannot perform a laboratory activity , and others that can be performed in laboratory in a simple trial.

Next is the detailed list of experiments proposed by students in each category followed by a description of the context and possible reasons for selecting the problems.

Experiments Related to Water

- Determination of the content of chlorine in the water supplied by the government owned company. *The assumption behind this problem is that the water supplied is either without or with low concentration of chlorine in the water specially during the rainy season.*
- Determination of the pH of the water consumed by the majority of the population, from water wells and water supplied by the public company. *The assumption is that the water supplied is not within the recommended standard of acidity.*
- Absence of recommended distance between water wells and latrines. *It is inferred that there is ground water contamination due to short distance between the wells and latrines (less than 30 meters).*
- Use of physical and chemical processes to purify water. *The situation is that in the rainy season the appearance of the water supplied is not attractive - turbidity and odor.*
- Population is not using any product to purify the water. *Since most of the population use water wells and most of them improper for human consumption, they should treated with anti-septic products.*

Justification: In Mozambique about 40% of the population have access to mains supplied water which meet minimum drinking water standards, but during rainy season (October to March) some of the parameters are affected. The majority of the population in the cities and rural areas rely on water from rivers, lagoons or wells for consumptions and other needs. These water is usually consumed without prior purification treatment because of ignorance or lack of resources to buy the required products. Therefore every year many diseases and deaths are reported due to the consumption of improper/ contaminated water.

Experiments Related to Alcohol

- Determination of alcohol content in the alcoholic drinks sold in the market. My comments: *There are several types of alcohol drinks commercialized in local market, homemade or produced at the factory they either do not have specification about the content of alcohol or the information presented on the label is false.*
- High rate consumption of homemade alcohol without knowing percentage of alcohol it contains. My comments*: Due to low prices compared with the normal traded beverages and other alcoholic drinks, there is an increase in number of people consuming alcohol, most of them teenagers or unemployed people, posing high risk to their health.*

Experiments Related to Tobacco

- High rate of tobacco consumption. *The tobacco sold is the local market is either raw - produced in local farms or in the neighboring provinces or processed tobacco without any certification.*
- Determination of the amount of nicotine and tar in cigars/ cigarettes. *The assumption behind this purpose is that both the raw and the processed tobacco commercialized in the markets may contain higher level of nicotine than the normal certified tobacco.*

Justification: There is a proliferation of illegally manufactured tobacco which is then sold in the market at cheaper price. As there is no control over the sale of these cigarettes they are often bought by teenagers. In addition to that, there are families who get their income from producing tobacco leaves to sell to tobacco companies for processing, often sell the rejected raw leafs on to gain some income and recover the money and effort invested.

Experiments Related to Plastics

- What are the consequences of using plastic bag to cover food when cooking?

- How to minimize the effects derived from burning plastic when lighting up coal or wood fire? *In most suburbs of the city, people with low income use plastic to light charcoal or wood to cook. In addition to that plastic bags are used to increase the heat when cooking food.*

Justification: Due to its combustibility and lack of legislation to curb the use of plastics, this material is available to any citizen and largely used by the population. The plastics are often used to cook (cover the top layer of the food when cooking rice, potatoes and other carbohydrates) to increase the heat. It is also used to light up fire of wood or charcoal because of it strong effectiveness compared to matches.

Experiments Related to Soil

- Determination of soil fertility in areas around Chimoio. *Chimoio and its surrounding is used by the population to farm different types of crops with good harvesting, most of them without using fertilizers.*
- How to prevent or fight soil erosion? *Chimoio is located on a plateau, and due to that and bad settlement of the population the city is prone to soil erosion.*
- How can we fight the soils containing the microorganism that cause foot disease caused by *Flea Chingoe* (*Tunga Penetrans*) "Matequenha". *In most of the suburbs of the city the population is affected by Flea Chingoe causing health problems specially in dry season (March to October).*

Justification: The city is highly productive and was once considered food basket of the country due to its fertile soils and good agro climacteric conditions (mild weather and many rivers and lagoons). Now the city does not live up to the expectations and many people believe that the soil lost its fertility and/or it is contaminated with microorganisms that cause diseases.

Experiments Related to Environmental Problems

- Chronic destruction of biomass. *Once the city was surrounded by forest and with the exponential increase of the population it put lot of pressure to this natural resource which is used for construction and wood fuel.*

- Recycling of the solid waste produced in Chimoio. *The city council does not have functional system of waste management, because of that the garbage produced is not properly transported, deposited and managed. Because of that one of the solution to the problem is recycling, reduce and reuse.*
- Identification of the active principle in the DDT. *This powerful pesticide is still used, despite some environmental problems well documented of its effect. It is the contention of the proponents of this problem to identify the active principle in this pesticide.*
- Production of homemade insecticide (*Aloe Vera*) to prevent trees from being attacked by ants. *Aloe Vera is commonly used by the population to protect plants against the attack of ants. This product is accessible to most of the population and its seems to have the desirable impact.*
- How to fight the microorganism that cause foot disease " Matequenha"Tungiasis? *For the flea problem the ideal is to find homemade medicines or drugs to cure the problem.*
- Prevention of water pollution by mercury (Hg) derived from gold mining in Manica district. *The illegal mining is one of the practice that occur in Manica, and in this process mercury is used for amalgamation process in river water, causing pollution.*

Justification: One of the biggest environmental problems felt by the citizens of Chimoio is related to the destruction of trees for fire wood for domestic use (cooking) and for industrial processes (the biggest textile factory of the country was established in 1952 and dismantled in 1990 and the only source of energy used was wood from the forest). Other environmental problems are related to soil erosion and the search for alternatives to curb the high prices of chemical fertilizers and insecticides, and also the problem of waste disposal and management. Those are perceived environmental problems that concern most students, rather than global environmental problems related to air pollution, alternative sources of energy or genetic modified food.

Experiments Related to Agriculture and Food Processing

- How to process agricultural surplus products like tomatoes and bananas?

- How to prevent tomatoes from getting rotten?
- How can we use milk produced in family sector to produce cheese?
- How to preserve the fruits to last long and prevent them from rottening.
- Determination of energetic content of the food consumed in Chimoio.
- How to produce organic fertilizer to use for fruit trees to improve the harvest?

Justification: The Manica Province was renowned as the granary of the country because it used to be the leading producer of maize, milk and other dairy products, and citrus fruits. Now the province is struggling to keep this status, while at the same time struggling to manage an agricultural surplus that get rotten, because there is no market to sell or there is no agro-processing industry or established value chain to use the goods as feedstock.

Experiments Related to Social Issues

- How can we prevent teenage pregnancies?

Citing the National Statistic Institute - INE (2014) the country has about 54% of the population living in absolute poverty (living on less than $1.5 USD/day per person), of this more than 55% are woman. One of the problem in cities and rural areas is pregnancy of teenagers which in most cases prevent them continuing with school education for those who are enrolled and prevent other from entering because of their status.

Experiments Related to Health Problems.

- How to identify the active principle on the plant used to brush teeth? *As an alternative to lack of financial resource to buy toothbrush and tooth paste the population frequently use roots or steams of certain plant for their mouth hygiene. Although the effect seems to be very positive it is important to determine the active principle in those plants as well as to determine the possible side effects.*
- Health problems derived from the consumption of poultry produced by the major producer of Chimoio. *The biggest poultry producer of the country is based in Chimoio. The fear and suspicion of most consumers is that the process of production of chickens and eggs some toxins and chemicals may be added and may cause*

health problems (problem that occur in other countries). It is the contention of this study to identify possible substances added to feed chickens and try to evaluate its effect to human beings.

- Remedies to cure stomach problems. *Due to exposition to not safe water and not well protected and preserved food, most of the population suffer from stomach problem. In this problem it is in contention to find alternative remedies to cure the problem.*

With the problems posed above and taking into account the context they were identified and based on the justification for their selection, students were ready to perform laboratory activities according to the conditions provided by the institution in the branch where the intervention occurred in both tiers: the first in 2012 and the second in 2013.

6.5. Description of the Learning Environment

6.5.1. Conditions in which the Study was Carried Out

The description presented below is made based on the assumption that the outcome of the intervention was strongly influenced by the classroom environment as noted by Fraser (2010), quoting evidence-based claims about its role on students.

The description of the learning environment will focus on three (3) aspects: (1) duration of the lessons; (2) the conditions in which the intervention was made, (3) types of interactions that occurred during the intervention period.

Duration:

The experiments were performed in the afternoon after the normal classes in the morning. The period of actual practical work was eight (8) weeks, 3 times per week in determined days, because the laboratories were used by other students, and each session would last between 120 and 150 minutes.

It is important to point out that some organizational problems occurred on several occasions: on some days scheduled to perform practical work per group they were not performed, either because the lab was occupied for unscheduled activities, or because students requested to postpone the laboratory activities because of test or other activities related to their normal activities in the course they were enrolled at university.

Irrespective of any unpredicted events the planned activities should be carried out within the 8 weeks period, therefore students were requested to reschedule their activities on other days.

Each weekday scheduled to do practical work the researcher would go to the laboratory, and observe students in groups performing practical work. Some of the activities like group discussion and debate were done in a normal classroom and the laboratory was only used to perform experiments.

Learning environment:

In this research learning environment should be understood as conditions in which the intervention occurred, it includes classroom and laboratory with all the instruments and apparatus. in fact, the whole intervention process was designed to take place in a conventional chemistry laboratory, using different approaches of laboratory equipment (micros-science kits; mini lab equipments and normal sized equipment). Since the Pedagogical University did not have any laboratory (it was under construction in a new building), the idea was to implement at another university (catholic university) where the students used to do practical work in their course, under an agreement between the two institutions.

In 2012, from the initial situation in which the experiments supposed to be performed in a laboratory of another University which was well equipped and with water and gas connected, the group had to be moved due to bad relationship between the two universities. With this setback, and with the willingness to do practical work, students were forced to use a secondary school laboratory. It was in this laboratory that students performed all the experiences proposed in year 2012, and since the situation did not change the intervention in year 2013 was also done in the same school laboratory.

The school laboratories had basic equipment and apparatuses, but there was no gas connection nor running water. Despite that, in order to expand the range of materials to perform the proposed experiments, in addition to the conventional equipment of the school laboratory, students had at their disposal mini laboratory equipment and micro-science kits, as well as stored chemicals and materials from Pedagogical University. The equipment available to students were of three types: normal size of lab equipment, mini-laboratories and micro science-kits, all of them used either in laboratory or normal classroom in their normal lessons at University. Some laboratory activities were videotaped and in all of them field notes were taken to observe the following aspects:

- Student-student relationship during the group discussion: presentation of individual ideas and defending of them; how easy or difficult they could accept other colleague's idea;
- Teacher-student relationship: how the teacher moderated or helped the students in groups to overcome difficulties.
- Student-internet/literature: to see whether prior the laboratory work students did an internet search or literature research about the proposed problems and experiments.

To have a grasp about the learning environment see ***appendix 10*** showing some photos of the laboratory and type of apparatus and materials used to perform laboratory activities.

Below it is given a further descriptions of the learning environment by focusing on the interactions between the key players in the intervention process according to the design devised.

6.5.2. Types of Interaction in the Learning Environment

As referred before doing practical work in an effective way should involve both "hands on" and "minds on" (Bradley, 2000). One of the main goals of this study and underpinning the whole intervention process was to propose the STS approach of teaching, using the inquiry type and open ended approach of practical work.

All the activities carried out prior to the intervention process - seminars about STS and about practical work - were designed to ensure that students will acquire theoretical and functional knowledge and skills to use STS approach, done through inquiry type and open ended approach to practical work.

In the Intervention process the task to all students was: ***based on the problems identified and that can be solved by means of laboratory activity - design, assemble and perform the practical work***. The assumption and the guiding learning theory is constructivist in which the student is at the center and plays a leading role in all process. Thus, there are three stances of students' interactions below described.

Student - Literature/ Internet:

After identifying problems to be researched and confirm with the government and municipality authorities related to the problem that it exists and it was among their priorities, students in groups were requested to do literature and internet research about the problems posed and encouraged to find plausible solutions .

From what was observed it can be inferred that the contact with the institutions that dealt the problems posed was very preliminary - just to confirm the existence of the problem and if it was among priorities of the sector. The step forward - what policies were in place to solve them and what problems they faced was not very effective. The possible reasons for that may be attributed to a lack of time for students to interview responsible sectors, because they were busy with classes in the morning and in afternoon they were occupied performing practical work three times a week, as requested and planned for this research.

According to observation made in the process, the literature and internet search was conducted focusing mainly on the experimental side of the problems posed with special emphasis on chemical aspects rather that interdisciplinary approach. Furthermore, the search was not in depth enough to look at other related aspects, such as the social and historical context, or make an effort to bring in knowledge from other natural sciences such as biology, physics and physical geography. As result of this superficial search, students were not equipped with enough knowledge to discuss the problems posed within a broader background and deep content knowledge. There were cases were they would start discussing issues related to the problems and give up the practical work because they did not know how to perform it (the procedures and equipment required), or engage in a discussion of peddling issues that would not lead to set up and perform a practical work.

Overall it can be concluded that the internet and literature search was superficial and lead to students not having enough background knowledge to perform some of the experiments proposed and solve the problems identified. Because of this problem, it is worth to assume that one of the goal of the whole intervention process was hindered, mainly because students would not use the theory from regular science class during laboratory activities - integration of knowledge (Fraser, 2010).

Student - student Interaction:

In an inquiry type of practical work, suing an open-ended approach students were expected to develop, both science basic skills and science integrated process skills. The key feature of the open ended approach here is that they did not know the results of what they supposed to get before starting laboratory activities.

To succeed in this approach it was important to have guidance from the researcher, and create and encourage students to have intense and fruitful discussion and debate of ideas in each group. Each students should have a say to participate actively in the practical work to be performed. In order to do so, prior to each practical work there was a need to prepare, either by literature/internet search or organize the issues to discuss with others in the group, and students asked each others to explain their ideas. Finally, they work with other students to design, assemble and perform laboratory activities (Fraser, 2010).

From the observation made during this process it was possible to observe that the dynamic of the group discussion was not as desirable. There was timid and ashamed attitude to expose and explain personal ideas to colleagues. This associated with lack of solid background about the problem to be solved, students would get stuck before even starting studying ways to overcome the problem. They were very dependent on the teacher whom they often ask for help before exhausting all means to seek for solution amongst themselves. Furthermore, when there were divergences, instead of pondering and bringing arguments to confront the opposite idea, the most frequent tactic used was to give up and accept colleagues' idea. By doing so, the debates were not heated in groups and it was possible to spot one or two leaders who would direct all the actions of the group and others followed passively.

Overall it can be concluded that the group discussion occurred, but was not as fruitful as it should be because did not occur the confrontation of ideas and bring arguments during the debates and discussions.. This attitude of students may be attributed to their prior experience throughout the schooling in which the teacher had the leading role and students are followers with little to say about the teaching subject.

Teacher - Student Interactions:

In an inquiry type of practical work using open-ended approach, students have total freedom to decide about a laboratory activity: decide about the instruments, assemble and perform the experiments. The role of teacher is to facilitate students to perform the practical work, giving the technical guidance and support about the use of some instruments and apparatus, and overseeing all the activities performed in the laboratory to avoid incidents.

The students' difficulties to perform the purposed laboratory activities were related to lack of experience to handle properly instruments and chemicals; lack of abilities to overcome difficulties to fulfill predefined procedure, and difficulties to integrate knowledge from other disciplines to control or eliminate some variables.

In overall, it was difficult for the teacher to play the role of facilitator, because students constantly ask questions for guidance or needed his intervention to solve disagreements among the students in the group. Despite an effort to stay aside, in most of the cases he had to intervene; otherwise the groups would not move forward with exploring different ways of performing practical work with the experiments proposed.

Based on the observations made during the experiments in the laboratory, it can be concluded that although students identified and proposed the experiments to be performed by themselves, most of them were performed with substantial guidance the researcher, more than it was planned in this inquiry type of practical work using open-ended approach. Therefore, it can be inferred that these difficulties can prevent students to acquire integrated science process skills such as hypothesizing, controlling variables and make inferences from the data gathered.

See ***appendix 9*** showing student-student interaction and teacher-student interaction when performing laboratory activities.

6.6. The VOSTS Items used in the Intervention

As it was presented in chapter IV - Research Methodology - and stated at the beginning of this chapter the intervention process was made in two tiers in two consecutive years - 2012 and 2013, using 13 VOSTS items selected from the pool of the 114 VOSTS items.

The thirteen (13) VOSTS items selected for the intervention has seven (7) similar items with the ones used in the baseline study, and follow the same pattern: to cover as many areas as possible without losing the focus on the aims of the intervention. Unlike the baseline, they cover four (4) of the 8 topics covered by all the 114 VOSTS items.

The main change from the VOSTS items used in the baseline and in the intervention was removing 6items: 3 related to science and technology viewed in Society; 1 related to views of Science in Medias and Science Classes, and 2 related to Technology, Development and Implementation. Six new VOSTS item were added all related to Epistemology dealing with the nature of scientific knowledge.

The rationale for replacing the items is because of the way the intervention was designed: with the removed items it would be difficult to assess the impact of the intervention made. On the other hand, the new items could yield information about the impact of the intervention made based on inquiry type of practical work, using open-ended approach in order to develop science integrated process skills - both incorporated in the 6 items about epistemology and nature of scientific knowledge.

The table below show the 13 VOSTS items used in the intervention classified into four (4) areas covered:

Nr.	VOSTS Number	VOSTS Area Covered and Question Statement
		Basic Definitions of Science and Technology
01	**10111**[a]	Defining science is difficult because science is complex and does many things. But MAINLY science is:
02	**10211**[a]	Defining what technology is, can cause difficulties because technology does many things in Canada. But MAINLY technology is:
		External Sociology of Science: Influence of Science and Technology for the Society
03	**20511**[a]	The success of science and technology in Mozambique depends on us having good scientists, engineers and technicians. Therefore Mozambique should require students to study more science in school.
		External Sociology of Science: Science and Technology viewed in Society
04	**40217**[a]	Scientists and engineers should be the ones to decide on world food production and food distribution (for example, what crops to plant, where best to plant them, how to transport food efficiently, how to get those who need it, etc.) because scientists and engineers are the people who the facts best.
05	**40311**[a]	We always have to make trade-offs (compromises) between the positive and negative effects of science and technology.
06	**40611**[a]	The most powerful countries of the world have strength because of the country´s superior science and technology.
07	**40711**[a]	Science and technology influence our everyday thinking because science and technology give us new words and ideas.
		Epistemology: Nature of Scientific Knowledge.
08	**90111**[a]	Scientific observations made by competent scientists will usually be different if the scientists believe different theories.
09	**90611**	When scientists investigate, it is said that they follow the scientific method. The scientific method is:
10	**90631**	Scientific discoveries occur as a result of a series of investigations, each one building on an earlier one, and each one leading logically to the next one, until the discovery is made
11	**90711**	Even when making predictions based on accurate knowledge, scientists and engineers can tell us only what *probably* might happen. They cannot tell what will happen for certain.
12	**91013**	For this statement, assume that a gold miner "discovers" gold while an artist "invents" a sculpture. Some people think that scientists *discover* scientific THEORIES. Others think that scientists *invent* them. What do you think?
13	**91121**[a]	Scientists in different fields look at the same thing from very different points of view (for example, H+ causes chemists to think of acidity and physicists to think of protons). This means that one scientific idea has different meanings, depending on the field a scientist works in.

Table 38: The VOSTS items used in the intervention and areas covered.

[a] = VOSTS item categorized in other studies and adopted in this study.

Experts' Scoring Scheme.

In chapter IV - Research Methodology - is presented a full description about the scoring scheme devised from a panel of experts, and it is worth to present some key features.

To assess students' responses, a scoring scheme was devised based on three categories: ***Realistic/ Has Merit /Naïve***, suggested by Rubba *et al.* (1996). A fourth category, ***Passive,*** was added to sum up the last three options common in all VOSTS statements: "I don't understand"; "I don't know enough about this subject to make a choice", and "None of these choices fits my basic viewpoint". The label ***Passive*** to label the last three options of VOSTS items was first suggested and used by Ben - Chaim & Zoller (1991) in their scoring scheme to assess responses to VOSTS.

A group of six (6) senior lecturers was identified to devise the scoring scheme to assess students' responses. All the six experts held a PhD degree and more than twenty years lecturing experience at university in Mozambique, being: 3 from chemistry course, 1 from biology course and 1 from physics course, and one from Germany.

Of the six experts only one was acquainted with STS approach having used it extensively for teaching and carrying out research using this approach. All other five (5) experts although some have heard about STS, had never worked with it. Despite that they were selected because they were the most senior lecturers in their courses at Pedagogical University in Mozambique with deep subject knowledge and work experience in different subjects at university which give them the background to categorize the VOSTS items.

Each expert was given the 13 VOSTS items with all the options, excluding the last three. Then, after a clarification of what the terms ***Realistic*** view , ***Has Merit*** and ***Naïve*** view mean, they were assigned the task to classify the options by choosing only one that they consider the Realistic view, and could classify other options as Has Merit or Naïve more than one time.

As a result of this process, naturally there were discrepancies on the choice of Realistic view, as well as in the classification of other options as Has Merit and Naïve made by the experts. To sort out those discrepancies the most chosen options were used to define the final line up of categories from the experts.

After obtaining the final scores from the experts, for the same VOSTS items used in other studies and categorized by a panel of judges, in the options where the categorizations were different the scoring scheme made by the panel of experts acquainted with STS issues was adopted and used in this study. Unfortunately, this was done only in nine (9) of the thirteen (13) VOSTS items used in other four (4) VOSTS items the scoring scheme rely solely on the experts' categorization identified in this study.

Item	Category			
	Realistic	Has Merit	Naïve	Passive
Q_1: 10112[a]	C	ABF	DEG	HIJ
Q_2: 10211[a]	G	BDEF	A	HIJ
Q_3: 20511	C	ABCD	EFG	IJK
Q_4: 40217[a]	D	CEF	ABG	HIJ
Q_5: 40311[a]	C	ABGD	EFH	IJK
Q_6: 40611[a]	F	ACE	BD	GHI
Q_7: 40711[a]	E	ABCD	F	GHI
Q_8: 90111 [a]	B	AC	DE	FGH
Q_9: 90611	J	GHI	ABCDEF	KLM
Q_{10}: 90631	D	ABCE	FG	HIJ
Q_{11}: 90711	A	BE	CD	FGH
Q_{12}: 91013	D	EF	ABC	GHI
Q_{13}: 91121[a]	B	AD	CE	FGH

Table 39: Experts' categorization of VOSTS items used in the intervention**.**

[a] = VOSTS item categorized in other studies and adopted in this study.
(The first 7 Questions were used in the Baseline Study).

6.7. Students' Views and Beliefs about STS in Pretest and Post-test

This sub-chapter will present students' responses in pretest and post-test in first tier year 2012 and second tier year 2013. The approach used is presenting combined data from pretest and post-test, of both years.

Taking each year separately there are opposite situations: in the year 2012 the number of student who responded to the questionnaire reduced from pretest (36) to post-test (33); while in the year 2013 the number increased from 26 to 33. Thus, only those students who answer both pretest and post-test were considered, which means that the sample for year 2012 was 33 and for year 2013 it was 26, a total of 59..

Taking each year separately the sample size would be less than 35 (33 in the year 2012 and 26 in the year 2013), the increasing of sample size to 59 increases the reliability and validity of the inferences and conclusions drawn based on statistical analysis.

6.7.1. Students' views Regarding the Definition of Science

This section presents the students' opinions about the definition of science. Excluding the last three options presented in the table below, the other seven statements (A to H) encompass views of science as: an instrument, satisfaction of curiosity; social enterprise and no definition for science.

Q_1: 10112. Defining science is difficult because science is complex and does many things. But MAINLY science is: **Your position, basically:** (Please read from A to K, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
A. A study of fields such as biology, chemistry and physics.	3,4	0	HM
B. A body of knowledge, such as principles, laws and theories, which explain the world around us (matter, energy and life).	37.3	30.5	HM
C. Exploring the unknown and discovering new things about our world and universe and how they work.	27.1	28.8	**R**
D. Carrying out experiments to solve problems of interest about the world around us.	6.8	6.8	N
E. Inventing or designing things (for example, artificial hearts, computers, space vehicles).	8.5	8.5	N
F. Finding and using knowledge to make this world a better place to live in (for example, curing diseases, solving pollution and improving agriculture).	10.2	13.6	HM
G. An organization of people(called scientists) who have ideas and techniques for discovering new knowledge.	1.7	3.4	N
H. No one can define science.	1.7	3.4	N
I. I don't understand.	3.4	5.1	P
J. I don't know enough about this subject to make a choice.	0	0	P
K. None of these choices fits my basic viewpoint.	0	0	P

Table 40: Pretest and Post-test students' opinions regarding definition of science

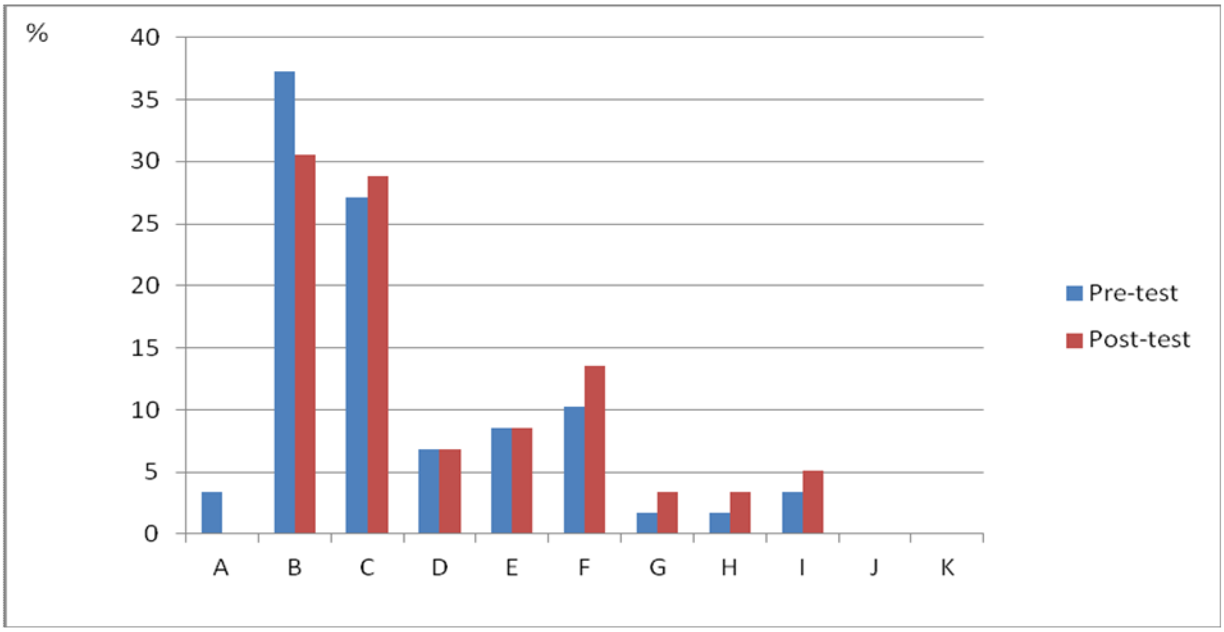

Figure 20: Pretest and post-test students' opinions regarding definition of science**.**

From the data presented in the table 40 and in the graph above, it can be seen that in both, pre and post-test, the three most chosen options are similar, and the first and third most chosen options, respectively B and F, are considered Has Merit, while the second most chosen category in both pre and post-test is considered the Realistic view.

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q1	59	0.52	0.045	- 0.444	0.679
Post Q1	59	0.50	0.049	(0.65)	(0.000)

Table 41: Pretest and post-test statistic results in question 1

According to the results from the statistical analysis performed and presented in the table above, it can be seen that p = 0.65, and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer patterns pretest and post-test.

From this result it can be concluded that the intervention made did not improve the students' views regarding the definition of science. In overall students' opinions are closer to what is accepted in scientific community about the definition of science. These findings are similar to the results of the baseline study about the same VOSTS item.

In summary, this VOSTS item was also used in the survey and was about the definition of science. According to the findings in pretest and post-test, students view science as an instrument or a finished product, rather than ***a process or something intrinsic to human nature to explore the unknown***. This view might be related to the nature of science curriculum taught in Mozambican schools. These findings are exactly the same as the one obtained in the survey on the same VOSTS item.

6.7.2. Students' views Regarding the Definition of Technology

This section gives Students' opinions about the definition of science. Excluding the last three options presented in the table below, the seven statements (A to G) encompass views of technology as follows: application of science, hardware; something social and done for human purposes; socio-economic and cultural components, and something like science.

	Q_2: 10211. Defining what technology is, can cause difficulties because technology does many things in Mozambique. But MAINLY technology is: **Your position, basically:** (Please read from A to J, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
A.	very similar to science.	3.4	3.4	N
B.	the application of science.	23.7	16.9	HM
C.	new processes, instruments, tools, machinery, appliances, gadgets, computers, or practical devices for everyday use.	35.6	37.3	HM
D.	robotics, electronics, computers, communication systems, automation, etc..	6.8	6.8	HM
E.	a technique for doing things, or a way of solving practical problems.	22.0	25.4	HM
F.	inventing, designing and testing things (for example, artificial hearts, computers, space vehicles).	1.7	3.4	HM
G.	ideas and techniques for designing and manufacturing things, for organizing workers, business people and consumers, for the progress of society.	6.8	6.8	**R**
H.	I don’t understand.	0	0	P
I.	I don’t know enough about this subject to make a choice.	0	0	P
J.	None of these choices fits my basic viewpoint.	0	0	P

Table 42: Pretest and post-test students' opinions regarding definition of technology

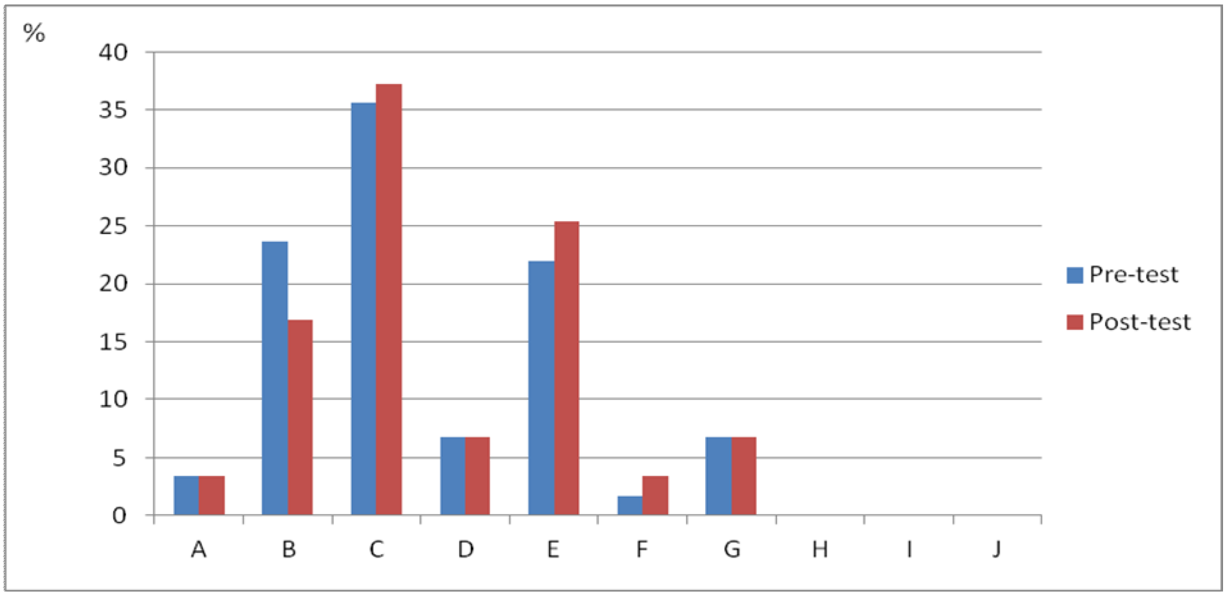

Figure 21: Pretest and post-test students' opinions regarding definition of technology**.**

The data presented in the table 42 and in the graph above show that C is the first most chosen option in pre and post-test and is considered Has Merit. The Second most chosen option in pretest is B and in post-test is E, and both options are considered Has Merit. The third most chosen option was E in pretest and B in post-test, and as referred both options are considered Has Merit. In this item neither in pretest nor in post-test the Realistic view is among the first three most chosen options.

These results are quite similar to the findings of Botton & Brown (1998), in the same VOSTS item, when studying 29 postgraduate trainee science teachers in England, in which the majority of the participants considered technology as application of science (option B).

	N	Mean	SE	Paired T Test	Correlation
Pre Q2	59	0.51	0.020	0.000	0.494
Post Q2	59	0.51	0.020	(1.000)	(0.000_

Table 43: Pretest and post-test statistic results in question 2

According to the results from the statistic analysis performed and presented in the table above, it can be seen that p = 1.00, and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern pretest and post-test.

From this result it can be concluded that students' views regarding definition of technology did not improve with the intervention. In overall their opinions are far from what is accepted in scientific community about the definition of technology. These findings are similar to the results of the baseline study about the same VOSTS item.

In summary, this VOSTS item was also used in the survey and was about the definition of technology. The results seems to suggest that pretest and post-test, students hold two broad views about technology: first, as something social done for human purposes, and the second view as the application of science. The most **appropriate view would be seeing technology as conception and manufacturing things for human purposes and for the progress of society.** These findings are exactly the same with the ones obtained in the survey on the same VOSTS item.

6.7.3. Students' Opinions about the Success in Science and Technology due to more Science in School

In this section, students' give their opinions on the requirement for more science and technology teaching in schools. Excluding the last three options presented in the table below, the six statements (A to F) encompass two opposite positions: the first that advocates that science should be mandatory, and the second that advocates that science should not be mandatory.

The table below summarizes students' responses in pretest and post-test:

Q_3: 20511 The success of science and technology in Mozambique depends on us having good scientists, engineers and technicians. Therefore, Mozambique should require students to study more science in school. **Your position, basically:** (Please read from A to K, and then choose one.)		**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
Students should be required to study more science:				
A.	Because it is important for helping Mozambique to keep up with other countries.	27.1	32.2	HM
B.	Because science affects almost every aspect of society. As in the past our future depends on good scientists and technologists.	37.3	33.9	HM
C.	Students should be required to study more science, but a different kind of science course. Students should learn how science and technology affect their everyday lives.	23.7	18.6	**R**
Students should NOT be required to study more science:				
D.	Because not all students can understand science, even though it would help them in their life.	1.7	0	HM
E.	Because not all students can understand science. Science is not really necessary for everyone.	1.7	0	N
F.	Because it's not right for someone else to decide if a student should take more science.	1.7	3.4	N
G.	I don't understand.	1.7	3.4	P
H.	I don't know enough about this subject to make a choice.	1.7	3.4	P
I.	None of these choices fits my basic viewpoint.	3.4	5.1	P

Table 44: Pretest and post-test students' responses about whether the success in science and technology is due to more science in school

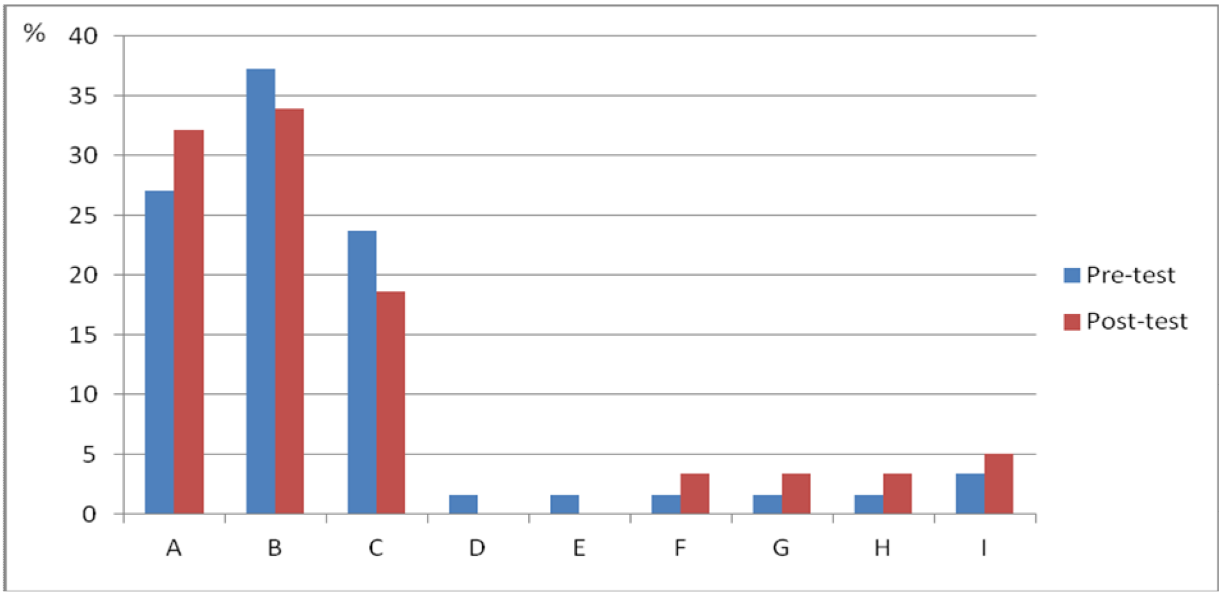

Figure 21: Pretest and post-test students' responses about whether the success in science and technology is due to more science in school.

From the table 44 and in the graph above it can be seen that the three most chosen options are similar pretest and post-test. The first option was B and the second one was A, and both options are categorized Has Merit. The third most chosen option was C and it is categorized Realistic view.

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q_3	59	0.56	0.037	- 0.893	0.462
Post Q_3	59	0.53	0.035	(0.376)	(0.000)

Table 45: Pretest and post-test statistic results in question 3

According to the results from the statistical analysis performed and presented in the table above, it can be seen that p = 0.38, and since it is greater than 0.05, it can be inferred that there is no significant difference between the answer pattern of pretest and post-test.

From this results it can be concluded that students' answer pattern pretest to post-test did not change significantly. The answer patter observed is similar with the results of the baseline study on the same VOSTS item. This means that the intervention made did not contribute to a change of their opinion on whether more school science should be included in schools to have more success in science and technology.

In summary, this VOSTS item was also used in the survey and was about whether having more science at school would contribute to have good scientists and engineers. The results seems to suggest that the overwhelming majority of students, both in pretest and post-test, believe that science should be compulsory at school, forwarding two broad reasons: first, because it has been always like that, and secondly because science affects our live. Both positions are not contrary to the believe about dissatisfaction with the current science content taught at school. These findings are exactly the same as the ones obtained in the survey on the same VOSTS item.

6.7.4. Students' Opinions about the Contribution of Scientists and Technologists to Social Decision

This section gives students' opinions about scientists' and engineers' role on decision-making about food production and distribution. The seven statements (A to G), excluding the last three, encompass three broad positions: technocratic or expert testimony; democratic decision-making (participation of all social stakeholders) and moral and legal decisions.

Q_4: 40217. Scientists and engineers should be the ones to decide on world food production and food distribution (for example, what crops to plant, where best to plant them, how to transport food efficiently, how to get food to those who need it, etc.) because scientists and engineers are the people who know the facts best. **Your position, basically:** (Please read from A to J, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
Scientists and engineers should decide:			
A. Because they have the training and facts which give them a better understanding of the issue.	18.6	15.3	N
B. Because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests.	6.8	10,2	N
C. Because they have the training and facts which give them a better understanding; BUT the public should be involved — either informed or consulted.	27.1	39.0	HM
D. The decision should be **made equally**; viewpoints of scientists and engineers, other specialists, and the informed public should all be considered in decisions which affect our society.	32.2	25.4	**R**
E. The **government** should decide because the issue is basically a political one; BUT scientists and engineers should give advice.	6.8	3.4	HM
F. The **public** should decide because the decision affects everyone; BUT scientists and engineers should give advice.	1.7	0	HM
G. The **public** should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic and narrow views on the issue and thus pay little attention to consequences.	1.7	0	N
H. I don't understand.	1.7	3.4	P
I. I don't know enough about this subject to make a choice.	1.7	0	P
J. None of these choices fits my basic viewpoint.	1.7	3.4	P

Table 46: Pretest and post-test students' responses regarding the contribution of scientist and technologists to social decisions

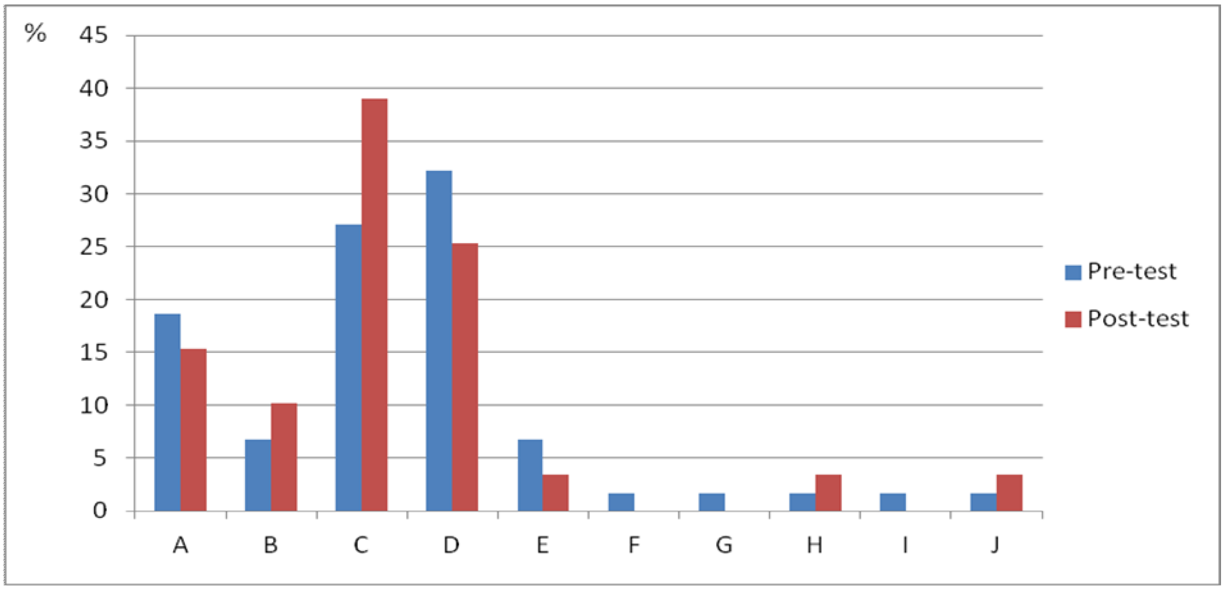

Figure 22: Pretest and post-test students' responses regarding the contribution of scientist and technologists to social decisions

From the table 46 and in the graph above it can be seen that the first most chosen option pretest was D, categorized as Realistic view and post-test it was C categorized Has Merit. The second most chosen option was C for the pretest and D for the post-test, and the categorization of both options is referred to in the previous period. The third most chosen option is A, and it is similar both pretest and post-test, and it is categorized Naïve view.

The results are almost similar to the ones obtained in Germany, using the same VOSTS item with about 3000 students aged 9 to 21, where the most chosen option was C (technocratic decision), and the second most chosen was the option D (Schallies *et al*, 2001).

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q_4	59	0.50	0.052	- 0.351	0.545
Post Q_4	59	0.48	0.048	(0.727)	(0.000)

Table 47: Pretest and post-test statistic results in question 4

According to the results from the statistical analysis performed and presented in the table above, it can be seen that p = 0.73, and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern pretest and post-test.

From this result it can be concluded that the intervention made did not contribute to a change of the answer pattern pretest to post-test. The answer patter observed is similar to the results of the baseline study on the same VOSTS item. This mean that the intervention made did not contribute to change students' opinions regarding the contribution of scientists and technologists.

In summary, this VOSTS item was also used in the survey and was about the leading role of scientists and technologists regarding food production and distribution. The results seems to suggest that, both in pretest and post-test, students believed that the decision should be equally shared with other stakeholders like the government and the public. This is a democratic approach to the decision-making on the issues that matter to society and it is considered an appropriate view. These findings are exactly the same as the ones obtained in the survey on the same VOSTS item.

6.7.5. Students' Opinions about the Influence of Science and Technology on Creation or Solution of Social Problems

This section gives Students' opinions about whether compromises between the positive and negative effects of science and technology should or should not be made. The eight statements (A to H) presented in the table below, excluding the last three options, encompass two broad positions: The first is that there is always trade-offs to be made, and the second one is that there is no compromise.

The table below summarizes students' responses from the pretest and post-test:

Q$_5$: 40311 We always have to make trade-offs (compromises) between the positive and negative effects of science and technology. **Your position, basically:** (Please read from A to K, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
There are always trade-offs between benefits and negative effects:			
A. Because every new development has at least one negative result. If we didn't put up with the negative results, we would not progress to enjoy the benefits.	33.9	32.2	HM
B. Because scientists cannot predict the long-term effects of new developments, in spite of careful planning and testing. We have to take the chance.	6.8	11.9	HM
C. Because things that benefit some people will be negative for someone else. This depends on a person s viewpoint.	10.2	16.9	**R**
D. Because you can't get positive results without first trying a new idea and then working out its negative effects.	16.9	16.9	HM
E. But the trade-offs make no sense. (For example: Why invent labour saving devices which cause more unemployment? or Why defend a country with nuclear weapons which threaten life on earth?)	1.7	0	N
There are NOT always trade-offs between benefits and negative effects:			
F. Because some new developments benefit us without producing negative effects.	22.0	0	N
G. Because negative effects can be **minimized** through careful planning and testing.	5.1	16.9	HM
H. Because negative effects can be **eliminated** through careful planning and testing. Otherwise, a new development is not used.	1.7	3.4	N
I. I don't understand.	1.7	1.7	P
J. I don't know enough about this subject to make a choice.	0	0	P
K. None of these choices fits my basic viewpoint.	0	0	P

Table 48: Pretest and post-test students' responses about the influence of science and technology on creation or solution of social problems

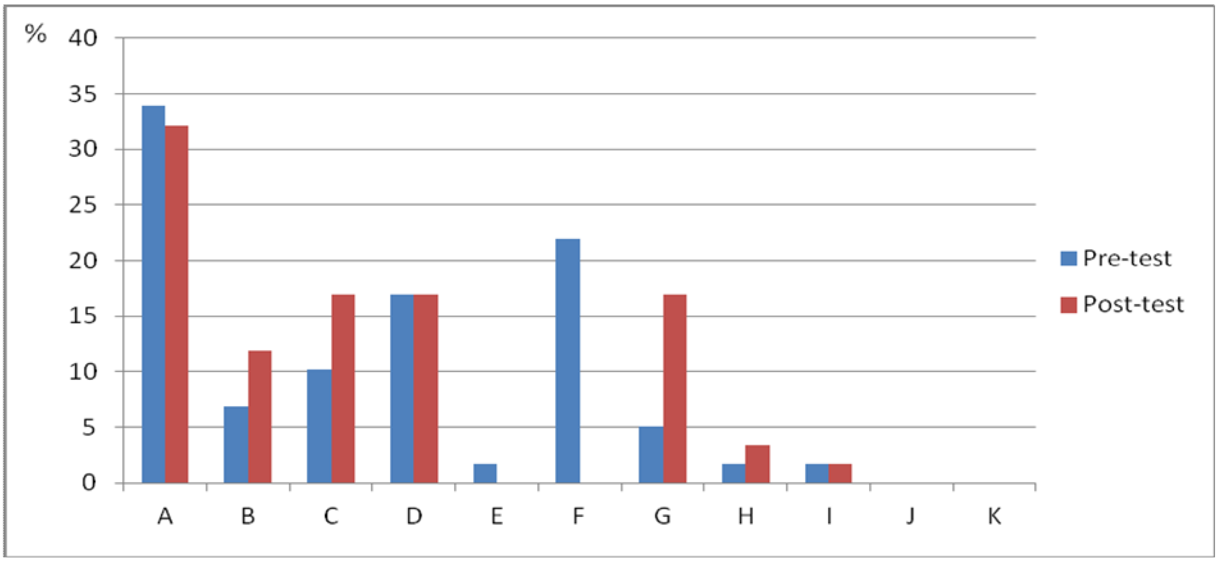

Figure 23: Pretest and post-test students' responses about the influence of science and technology on creation or solution of social problems**.**

The table 48 and the graph 18 above show that option A was the first choice both pretest and post-test and it is categorized Has Merit. The second most chosen option was F pretest, and three options were the second most chosen post-test with the same scores C, D and G, categorized respectively as Realistic and Has Merit for the last two.

	N	***Mean***	***SE***	***Paired T Test***	***Correlation***
Pre Q_5	59	0.41	0.038	1.929	0.600
Post Q_5	59	0.28	0.048	(0.059)	(0.000)

Table 49: Pretest and post-test statistic results in question 5

According to the results from the statistical analysis and presented in the table above, it can be seen that p = 0.06, and since it is greater than 0.05, it can be inferred that there is no significant difference between the answer pattern of pretest and post-test.

From these results it can be concluded that the intervention made did not contributed to change students' answer pattern about the Influence of Science and technology on creation or solution of social problems. The same answer pattern was observed in the baseline study in the same VOSTS item. Therefore, the intervention made did not contribute to change students' conceptions about the issue.

In summary, this VOSTS item was also used in the survey and was about whether there should have to make trade-offs between the benefits and negative effects of science and technology. The results seems to suggest that, both pretest and post-test, students believe we have to make trade-offs between the benefits and negative effects of science and technology, mainly because with every new development there is at least one negative result. This is partly true, but the appropriate view is the one that ***advocates that the positive and negative impacts of science and technology depend on a person's viewpoint.*** These findings are exactly the same as the ones obtained in the survey on the same VOSTS item.

6.7.6. Students' Opinions about the Relationship between Science and Technology with Military Power

This section gives students' opinions about whether there is a relationship between the level of scientific and technological development and the military strength of a country. The six statements (A to F) presented in the table below, excluding the last three options, encompass three broad ideas: there is a direct dependence, there is no direct dependence and there is dependence but not only on the level of development of science and technology.

The table below summarizes students' responses from the pretest and post-test:

Q_6: **40611. The most powerful countries of the world have military strength because of the country's superior science and technology. Your position, basically:** (Please read from A to I, and then choose one.)**:**	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
Military strength depends a **great deal on** science and technology:			
A. Because the greater the development in science and technology, the more modern, accurate and destructive the weapons..	35.6	39.0	HM
B. Because the military usually has a strong voice in government, and the military will insist on using science and technology to build its strength.	3.4	0	N
C. Because the more advanced the country's science and technology, the **richer** the country. Its money can be spent on making the military stronger.	22.0	20.3	HM
D. Military strength depends not only on science and technology for powerful weapons, but also on the size of its armed forces.	11.9	13.6	N
E. Military strength depends **partly on** science and technology and partly on a government s decision to develop weapons to increase its power..	11.9	8.5	HM
F. Military strength does **not** depend on science and technology, but on the government. Some countries which are strong in science and technology have weak militaries (for example, Japan). Some countries which have a strong military are weak in science and technology (for example, China).	5.1	3.4	**R**
G. I don't understand.	5.1	8.5	P
H. I don't know enough about this subject to make a choice.	3.4	6.8	P
I. None of these choices fits my basic viewpoint	0	0	P

Table 50: Pretest and post-test students' responses about the relationship between science and technology with military power of a country

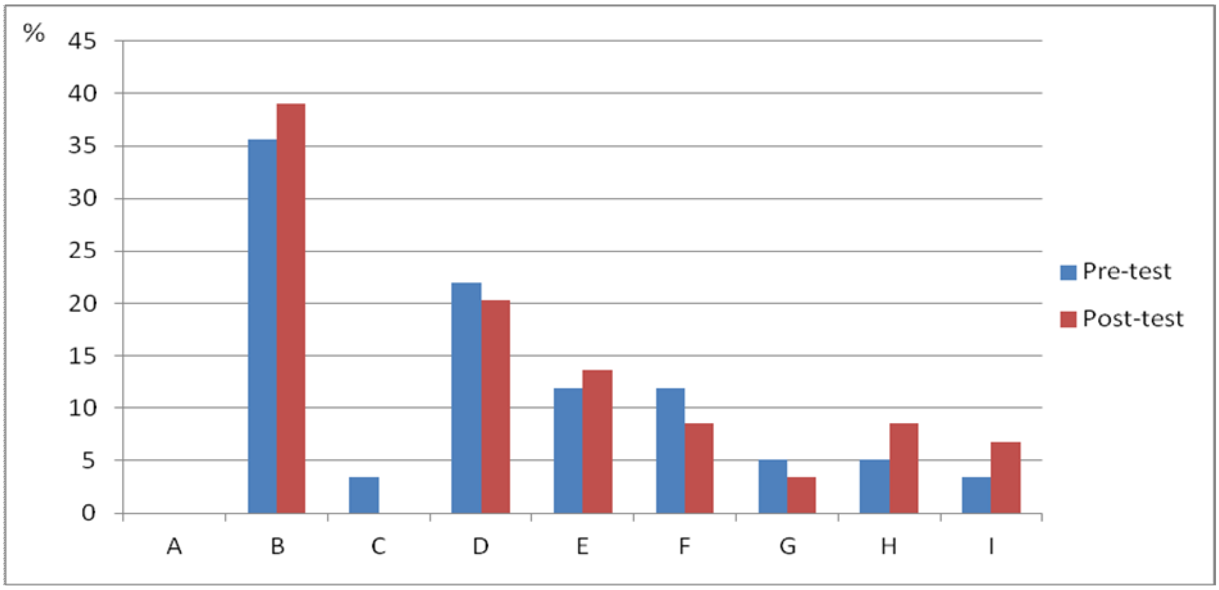

Figure 24: Pretest and post-test students' responses about the relationship between science and technology with military power of a country

From the data presented in the table 50 and in the graph above it can be seen that the most chosen option in both pretest and post-test is A, and it is categorized as Has Merit. The second most chosen option in both pretest and post-test is C and it is also classified as Has Merit. The third most chosen option in both pretest and post-test is D and is classified as Naïve.

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q_6	59	0.20	0.045	2.694	0.021
Post Q_6	59	0.36	0.039	(0.009)	(0.877)

Table 51: Pretest and post-test statistic results in question 6

According to the results from the statistical analysis performed and presented in the table above, it can be seen that p = 0.01, and since it is smaller than 0.05 it can be inferred that there is significant difference between the answer pattern of the pretest and post-test.

From these results it can be concluded that students' answer pattern changed significantly from the pretest to post-test. Therefore, it can be inferred that the intervention made did contribute to change student's conceptions about this issue. The same answer pattern was verified on the baseline study using the same VOSTS item.

In summary, this VOSTS item was also used in the survey and was about the relationship between the military strength of a country and its advancement in science and technology. The results seems to suggest that, in pretest and post-test, students believe that the military strength of a country depends directly on the development of science and technology. Their positions are based on linear impact of science and technology development to military power, and because the military will make their voice heard and make use of the advancement of science and technology of a country. Although these positions have some legitimate issues the most appropriate view is considered to be the one that ***places emphasis not only on the development of science and technology, but also on the size of its armed force***. These findings are exactly the same as the ones obtained in the survey on the same VOSTS item.

6.7.7. Students' Opinions about the Influence of Science and Technology and its Contribution to Social Thinking

This section gives Students' opinions about whether science and technology give us news words and ideas due to its influence on our everyday thinking. The six statements (A to F) presented in the table below, excluding the last three options, encompass two broad ideas are: the first, is affirmative advocating the that science and technology have great influence on our words and ideas and the second is the opposite.

Q_7: **40711 Science and technology influence our everyday thinking because science and technology give us new words and ideas.** **Your position, basically:** (Please read from A to I, and then choose one.)**:**	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
A. Yes, because the more you **learn about** science and technology, the more your vocabulary increases, and thus the more information you can apply to everyday problems.	22.0	15.3	HM
B. Yes, because we use the **products** of science and technology (for example, computers, microwaves, health care). New products add new words to our vocabulary and change the way we think about everyday things.	18.6	23.7	HM
C. Science and technology influence our everyday **thinking** BUT the influence is mostly from new ideas, inventions and techniques which broaden our thinking.	32.2	33.9	HM
Science and technology are the most powerful influences on our everyday lives, ***not*** *because of words and ideas:*			
D. but because almost everything we do, and everything around us, has i4.9n some way been researched by scienc5.3e and technology.	13.6	11.9	**R**
E. but because science and technology have changed the way we live.	6.8	8.5	HM
F. No, because our everyday thinking is mostly influenced by non-scientific things. Science and technology influence only a few of our ideas.	5.1	3.4	N
G. I don't understand.	1.7	3.4	P
H. I don't know enough about this subject to make a choice.	0	0	P
I. None of these choices fits my basic viewpoint.	0	0	P

Table 25: Pretest and post-test students' responses about the influence of science and technology and contribution to social thinking

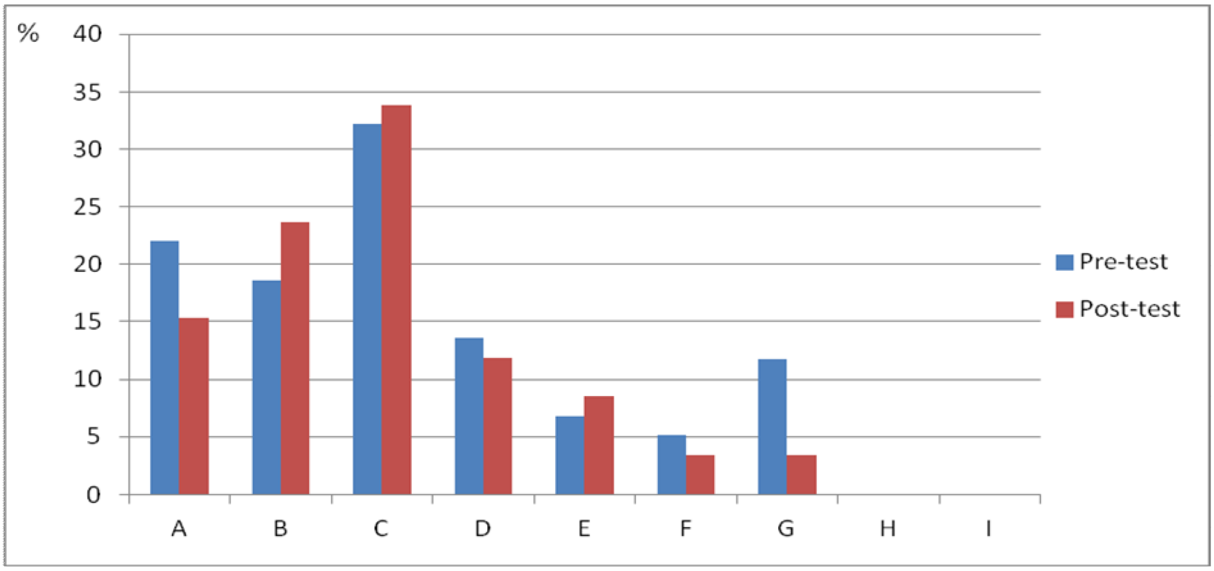

Figure 25: Pretest and post-test students' responses about the influence of science and technology and contribution to social thinking

From the table 49 and in the graph above it can be seen that the first choice is C both pretest and post-test and this option is considered Has Merit. The second most chosen option is A pretest and B post-test, and both options are considered Has Merit. The third most chosen option is B pretest and A post-test, and as referred in previous period both options are considered Has Merit. It is important to note that the Realistic view is option F and it is not amongst the first four priorities in both pretest and post-test answers.

	N	***Mean***	***SE***	***Paired T Test***	***Correlation***
Pre Q_7	59	0.50	0.024	0.444	0.708
Post Q_7	59	0.50	0.025	(0.659)	(0.000)

Table 53: Pretest and post-test statistic results in question 7

According to the results the statistical analysis performed it can be seen that p = 0.66. Since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern pretest and post-test.

From these results it can be concluded that the students' answer pattern did not change from pretest to post-test about the Influence of science and technology and its contribution to social thinking. . The same results were obtained in the baseline study on the same VOSTS item. Therefore, the intervention made did not contribute to change student's conception in this issue.

In summary, this VOSTS item was also used in the survey and was about whether the influence of science and technology to our everyday thinking give us new words and ideas. The results seems to suggest that, both in pretest and post-test, students believe that everyday thinking is influenced by new words from science and technology. This perception is partly correct, but the most appropriate one is to ***consider that everything surrounding us has been in some way researched by science and technology***. These findings are exactly the same as the one obtained in the survey on the same VOSTS item.

6.7.8. Students' Opinions about the Nature of Observations Made by Scientists

In this VOSTS item students were required to give their opinions about the nature of scientific observations made by scientist. The six options presented in the table below (A to F), excluding the last three, encompass two broad positions: the first, advocating that the scientific observation are theory free, and the second one advocates that the observations made are biased or theory laden.

Q_8: **90111 Scientific observations made by competent scientists will usually be different if the scientists believe different theories.** **Your position, basically:** (Please read from A to H, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
A. Yes, because scientists will **experiment** in different ways and will notice different things.	15.3	18.6	HM
B. Yes, because scientists will **think** differently and this will **alter their observations.**	25.4	27.1	**R**
C. Scientific observations will **not differ** very much even though scientists believe different theories. If the scientists are indeed **competent** their observations will be similar.	42.4	39.0	HM
D. No, because observations are as exact as possible. This is how science has been able to advance.	5.1	6.8	N
E. No, observations are exactly what we see and nothing more; they are the facts.	5.1	0	N
F. I don't understand.	1.7	3.4	P
G. I don't know enough about this subject to make a choice.	3.4	3.4	P
H. None of these choices fits my basic viewpoint.	1.7	1.7	P

Table 54: Pretest and post-test students' views about the nature of scientific observations

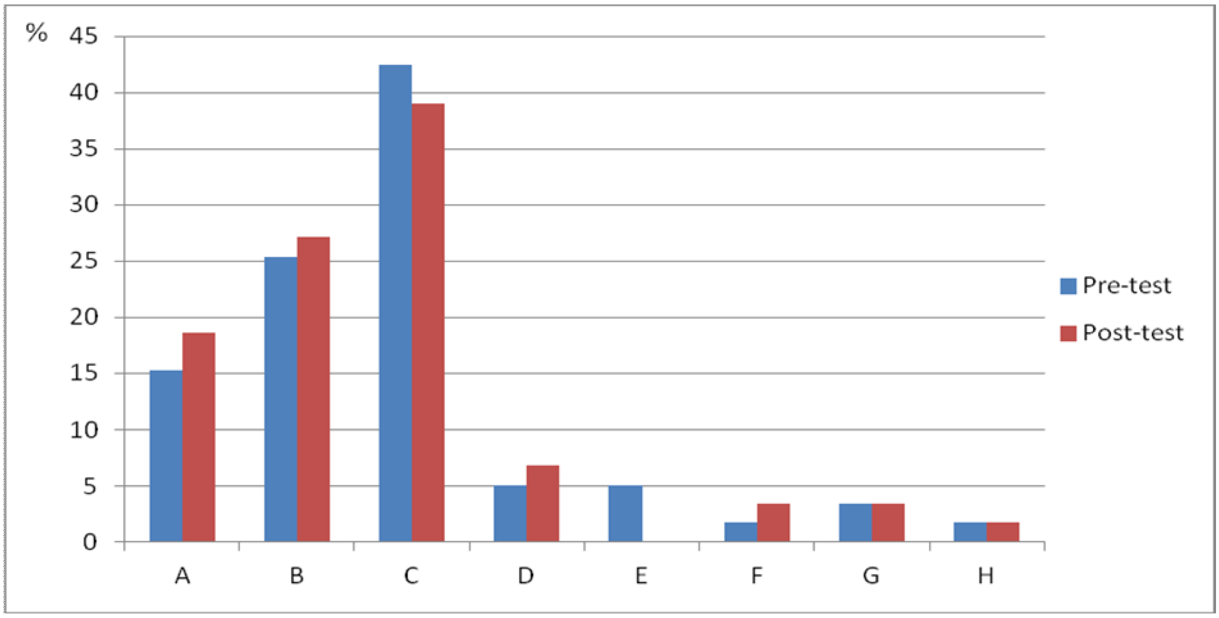

Figure 26: Pretest and post-test students' views about the nature of scientific observations

From the data presented in table 54 and in the graph above it can be seen that the first three choices made by students are similar pretest and post-test. The first option was C, the second was B and the third was A. Options A and C are considered Has Merit while option B is considered Realistic view.

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q_8	59	0.54	0.042	0.389	0.468
Post Q_8	59	0.55	0.042	(0.698)	(0.000)

Table 55: Pretest and post-test statistic results in question 8

According to the statistical analysis performed using SPSS shows that p = 0.70., and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern in pretest and post-test.

From these results it can be inferred that students' answer pattern is not significantly different pretest to post-test. Therefore, it can be concluded that the intervention made did not contribute to a change of students' opinions whether the nature of observations made by scientists would be different if the scientists believe different theories.

The literature is firm about whether the observations made by scientists are biased or not. The statement by Lederman *et al.* (2002, p.501) is clear about this issue:

> *"Scientific knowledge is theory-laden. Scientists***ô** *theoretical and disciplinary commitments, beliefs, prior knowledge, training, experiences, and expectations actually influence their work. All these background factors form a mindset that affects the problems scientists investigate and how they conduct their investigations, what they observe (and do not observe), and how they interpret their observations*."

From this statement it is clear that there is no such presumption that the observations made by scientists and purely objective and theory-free.

In summary, this VOSTS item was about whether the observations made by scientists are theory free or theory laden. The results seems to suggest that the majority of students, in both pretest and post-test, believe that scientific observations will not differ very much and that scientific observations are influenced by scientists believe and prior experience. These positions are considered acceptable in the scientific community, therefore it can be considered that students have Realistic View about this issue.

6.7.9. Students' Opinions Regarding the Definition of Scientific Method

In this VOSTS item students were required to give their opinions regarding the definition of scientific method when doing investigation. The eight options presented in the table below (A to H), excluding the last three, encompass three broad positions: the first, advocating a stepwise process, the second one is the absence of stepwise but use of logical thinking, and the third one as human endeavor.

The table below summarizes students' responses from the pretest and post-test:

Q_9: 90611 When scientists investigate, it is said that they follow the scientific method. The scientific method is: **Your position, basically:** (Please read from A to M, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
A. The lab procedures or techniques; often written in a book or journal, and usually by a scientist.	13.6	10.2	N
B. Recording your results carefully.	5.1	1.7	N
C. Controlling experimental variables carefully, leaving no room for interpretation.	3.4	6.8	N
D. Getting facts, theories or hypotheses efficiently.	10.2	15.3	N
E. Testing and retesting — proving something true or false in a valid way.	11.9	11.9	N
F. Postulating a theory then creating an experiment to prove it.	13.6	10.2	N
G. Questioning, hypothesizing, collecting data and concluding.	23.7	15.3	HM
H. A logical and widely accepted approach to problem solving.	6.8	13.6	HM
I. An attitude that guides scientists in their work.	8.5	10.2	HM
J. Considering what scientists actually do, there really is no such thing as the scientific method.	1.7	3.4	**R**
K. I don't understand.	1.7	1.7	P
L. I don't know enough about this subject to make a choice.	0	0	P
M. None of these choices fits my basic viewpoint.	0	0	P

Table 56: Pretest and post-test students' views about definition of scientific method

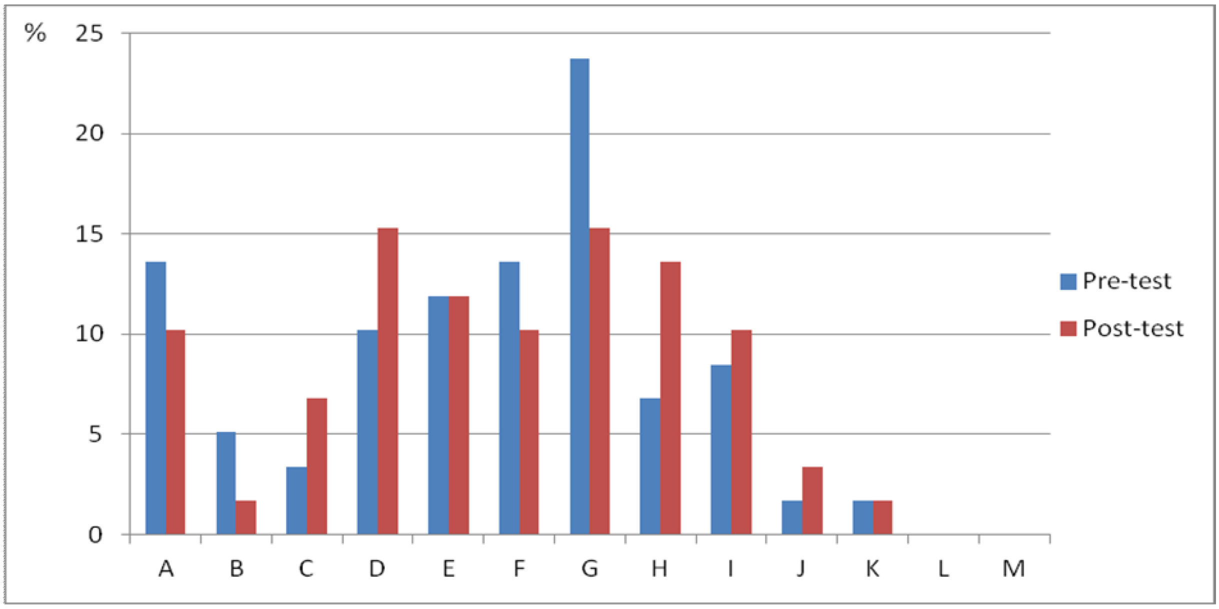

Figure 27: Pretest and post-test students' views about definition of scientific method

In the table 56 and in the graph above it can be seen that option G was the first choice both pre and post-test and it is considered Has Merit. The second most chosen options in pretest were A and F with the same number of students, both categorized as Naïve view, while in the post-test was H considered Has Merit. The third most chosen option was E in both pre and post-test and it is considered Naïve view. The considered Realistic view is J and is not among the first 5 choices in both pre and post-test.

	N	***Mean***	***SE***	***Paired T Test***	***Correlation***
Pre Q_9	59	0.32	0.055	- 0.562	0.330
Post Q_9	59	0.28	0.048	(0.576)	(0.011)

Table 57: Pretest and post-test statistic results in question 9

The statistical analysis performed shows that p = 0.58, and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern in pretest and post-test.

From these results it can be inferred there is no significant difference in students' answer pattern pretest to post-test. Thus, it can be concluded that the intervention made did not contribute to change Students' opinions about whether scientists follow scientific method when investigating.

To illustrate that there are many misconception about scientific method well established in many science books, one of its critic is Lederman *et al* (2002, p.501), as he stated:

> *"The myth of the scientific method is regularly manifested in the belief that there is a recipelike stepwise procedure that all scientists follow when they do science. ...There is no single scientific method that would guarantee the development of infallible knowledge. "*

From this statement it can be inferred that there is no such thing called scientific method, understood as following a single sequence of prescribed activities to acquire scientific knowledge. About the same issue Chen (2006), consider naive the view that there is universal scientific method.

In summary, this VOSTS item was about the definition of scientific method. The results seems to suggest that, both in pretest and post-test, students opinions vary from inquiry, open attitude to approach science and logical and widely accepted approach to problem solving. All three positions are considered acceptable in the scientific community, therefore can be considered Realistic view or Has Merit.

6.7.10. Students' Opinions about How Scientific Discoveries Are Made

In this VOSTS item students were required to give their opinions about how scientific discoveries are made. The seven options presented in the table below (A to G), excluding the last three, encompass two broad positions: the first advocating the stepwise process, and the second one advocating not following a logical series of investigations.

The table below summarizes students' responses from the pretest and post-test:

Q_{10}: **90631 Scientific discoveries occur as a result of a series of investigations, each one building on an earlier one, and each one leading logically to the next one, until the discovery is made. Y our position, basically:** (Please read from A to J, and then choose one.)**:**	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
Scientific discoveries result from a logical series of investigations:			
A. Because experiments (for example, the experiments that led to the model of the atom, or discoveries about cancer) are like laying bricks onto a wall.	10.2	11.9	HM
B. Because research begins by checking the results of an earlier experiment to see if it is true. A new experiment will be checked by the people who come afterwards.	18.6	16.9	HM
C. **Usually** scientific discoveries result from a logical series of investigations. But science is not completely logical There is an element of trial and error, hit and miss, in the process.	16.9	11.9	HM
D. **Some** scientific discoveries are accidental, or they are the unpredicted product of the actual intention of the scientist. However, **more** discoveries result from a series of investigations building logically one upon the other.	23.7	25.4	**R**
E. **Most** scientific discoveries are accidental, or they are the unpredicted product of the actual intention of the scientist. **Some** discoveries result from a series of investigations building logically one upon the other.	16.9	23.7	N
Scientific discoveries do **not** occur as a result of a logical series of investigations:			
F. Because discoveries often result from the piecing together of previously unrelated bits of information.	1.7	0	N
G. Because discoveries occur as a result of a wide variety of studies which originally had nothing to do with each other, but which turned out to relate to each other in unpredictable ways.	8.5	3.4	N
H. I don't understand.	1.7	3.4	P
I. I don't know enough about this subject to make a choice.	1.7	3.4	P
J. None of these choices fits my basic viewpoint.	0	0	P

Table 58: Pretest and post-test students' views about how scientific discoveries are made

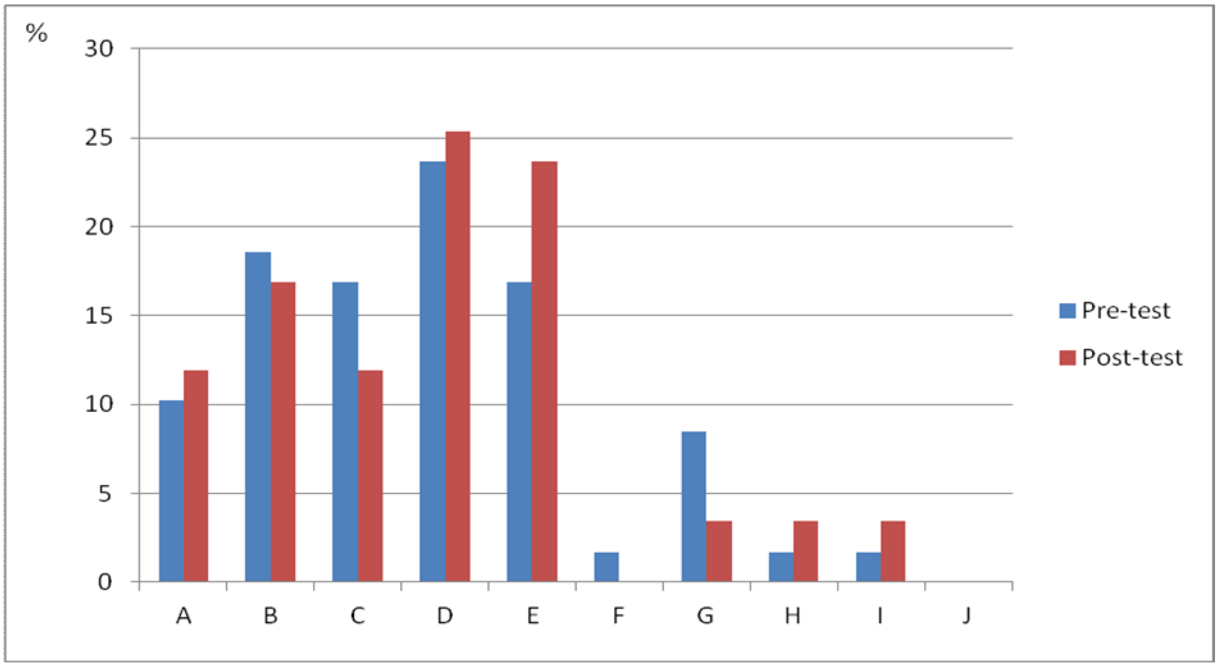

Figure 28: Pretest and post-test students' views about how scientific discoveries are made

From the data presented in the table 58 and in the graph above it can be seen that the most chosen option both pretest and post-test was D and it is categorized as Realistic view. The second most chosen option both pre and post-test was B and is categorized Has Merit. The third most chosen option was C pretest and A post-test, both options are considered Has Merit.

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q_{10}	59	0.55	0.039	0.622	0.443
Post Q_{10}	59	0.57	0.037	(0.536)	(0.000)

Table 59: Pretest and post-test statistic results in question 10

According to the results from the statistical analysis performed and presented in the table above, it can be seen that p = 0.54, and since it is greater than 0.05, it can be inferred that there is no significant difference between the answer pattern from pretest to post-test.

From these results it can be inferred there is no significant difference in students' answer pattern from pretest to post-test. Thus, it can be concluded that the intervention made did not contribute to a change in Students' opinions about how scientific discoveries are made.

In this VOSTS item, the first part of the statement is based on the assumption that the world we live is understandable, and this opinion is corroborated by the statement below:

> *"Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study. Scientists believe that through the use of the intellect, and with the aid of instruments that extend the senses, people can discover patterns in all of nature".* (AAAS, 1990, p.6)

Looking at the result of this study, it can be seen that most of the respondents accept that scientific discoveries result from a logical series of investigation, rather than a random and casual process.

In summary, this VOSTS item was about whether scientific discoveries occur as a result of series of investigations. The results seems to suggest that, both pre and post-test, students believe that scientific discoveries result from a logical series of investigations. This positions is considered acceptable in the scientific community, therefore it can be concluded that students hold Realistic view about this issue.

6.7.11. Students' Opinions about Students' Views about Certainty and Uncertainty of the Predictions Made by Scientists and Engineers

In this VOSTS item students were required to give their opinions about the certainty and uncertainty of predictions made by scientists and engineers when carrying out investigations The five options presented in the table below (A to E), excluding the last three, encompass two broad positions: the first advocating that the predictions are certain and the second supporting that predictions are never made with certainty.

The table below summarizes students' responses from the pretest and post-test:

Q11: 90711 Even when making predictions based on accurate knowledge, scientists and engineers can tell us only what *probably* might happen. They cannot tell what will happen for certain. **Your position basically:** (Please read from A to H, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
Predictions are NEVER certain:			
A. Because there is always room for error and unforeseen events which will affect a result. No one can predict the future for certain.	62.7	59.3	R
B. Because accurate knowledge changes as new discoveries are made, and therefore predictions will always change.	16.9	22.0	HM
C. Because a prediction is not a statement of fact. It is an educated guess.	3.4	6.8	N
D. Because scientists **never** have all the facts. Some data are always missing.	8.5	3.4	N
E. It depends. Predictions are certain, only as long as there is accurate knowledge and enough information.	8.5	8.5	HM
F. I don't understand.	0	0	P
G. I don't know enough about this subject to make a choice.	0	0	P
H. None of these choices fits my basic viewpoint.	0	0	P

Table 60: Pretest and post-test students' views about certainty and uncertainty of the predictions made by scientists and engineers

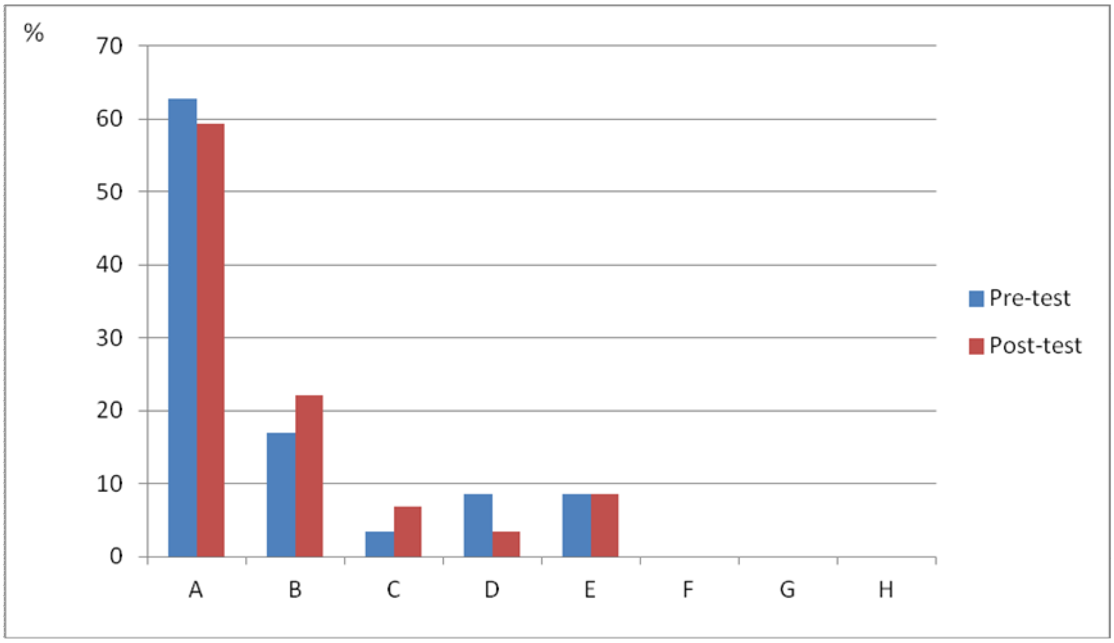

Figure 29: Pretest and post-test students' views about certainty and uncertainty of the predictions made by scientists and engineers

From the data presented in the table 60 and the in the graph above it can be seen that the first three choices are similar both pretest and post-test. The first most chosen option was A and is considered the Realistic view, while the second and third most chosen options were B and E, respectively, and both options are considered Has Merit.

	N	Mean	SE	Paired T Test	Correlation
Pre Q_{11}	59	0.75	0.045	- 4.854	0.136
Post Q_{11}	59	0.51	0.011	(0.000)	(0.303)

Table 61: Pretest and post-test statistic results in question 11

According to the results from the statistical analysis performed and presented in the table 58 above, it can be seen that $p = 0.00$, and since it is smaller than 0.05 it can be inferred that in this VOSTS item there is significant difference between the answer pattern of the pretest and post-test.

From these results it can be inferred that there is a significant difference in the students' answer pattern from pretest to post-test. Thus, it can be concluded that the intervention made contributed significantly to change the Students' opinions about whether scientists and engineers can tell us what might happen for certain or not.

Referring to the durability and certainty of scientific knowledge the AAAS (1990, p.5) stated:

> *"Although scientists reject the notion of attaining absolute truth and accept some uncertainty as part of nature, most scientific knowledge is durable. The modification of ideas, rather than their outright rejection, is the norm in science, as powerful constructs tend to survive and grow more precise and to become widely accepted."*

From the statement above we can infer that in the course of constructing scientific knowledge there are moments of uncertainties, and the knowledge obtained can always be subject to change. This twofold feature of scientific knowledge both as process and product can be observed throughout the history of science (Kuhn, 1970).

About the intrinsic relationship between theories and predictions made in the course of investigation, it is stated that:

> *"Scientists derive specific testable predictions from theories and check them against tangible data. An agreement between such predictions and empirical evidence serves to increase the level of confidence in the tested theory*. "(Lederman, 2002, p.500)

Taking both statements into account, we can consider that from the options given for this VOSTS item, many are acceptable (Has Merit), but the Realistic view is A.

In summary, this VOSTS item was about certainty and uncertainty of predictions made by scientists and engineers when carrying out investigations. The results seems to suggest that overwhelming majority of students, both in pretest and post-test, hold the view that scientific predictions are never certain. This view is shared with the scientific community about the issue, therefore it can be concluded that students have Realistic view or Has Merit about the issue.

6.7.12. Students' Opinions about whether Scientific Theories are Discovered or Invented

In this VOSTS item students were required to give their opinions about whether scientific theories are discovered or invented by scientists. The six options presented in the table below (A to F), excluding the last three, encompass two broad positions: the first advocating that theories are discovered and the other one supporting the idea that theories are invented.

The table below summarizes students' responses from the pretest and post-test:

Q_{12}: 91013 For this statement, assume that a gold miner "discovers" gold while an artist "invents" a sculpture. Some people think that scientists *discover* scientific THEORIES. Others think that scientists *invent* them. What do you think? Your position, basically: (Please read from A to I, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
Scientists **discover** a theory:			
A. Because the idea was there all the time to be uncovered.	5.1	10.2	N
B. Because it is based on experimental **facts**.	42.4	45.8	N
C. But scientists invent the **methods** to find the theories.	13.6	13.6	N
D. Some scientists may stumble onto a theory by chance, thus discovering it. But other scientists may invent the theory from facts they already know.	6.8	6.8	**R**
Scientists **invent** a theory:			
E. Because a theory is an interpretation of experimental **facts** which scientists have discovered.	23.7	15.3	HM
F. Because inventions (theories) come from the mind — we create them.	5.1	6.8	HM
G. I don't understand.	1.7	0	P
H. I don't know enough about this topic to make a choice.	1.7	1.7	P
I. None of these choices fits my basic viewpoint.	0	0	P

Table 62: Pretest and post-test students' views about whether scientific theories are discovered or invented

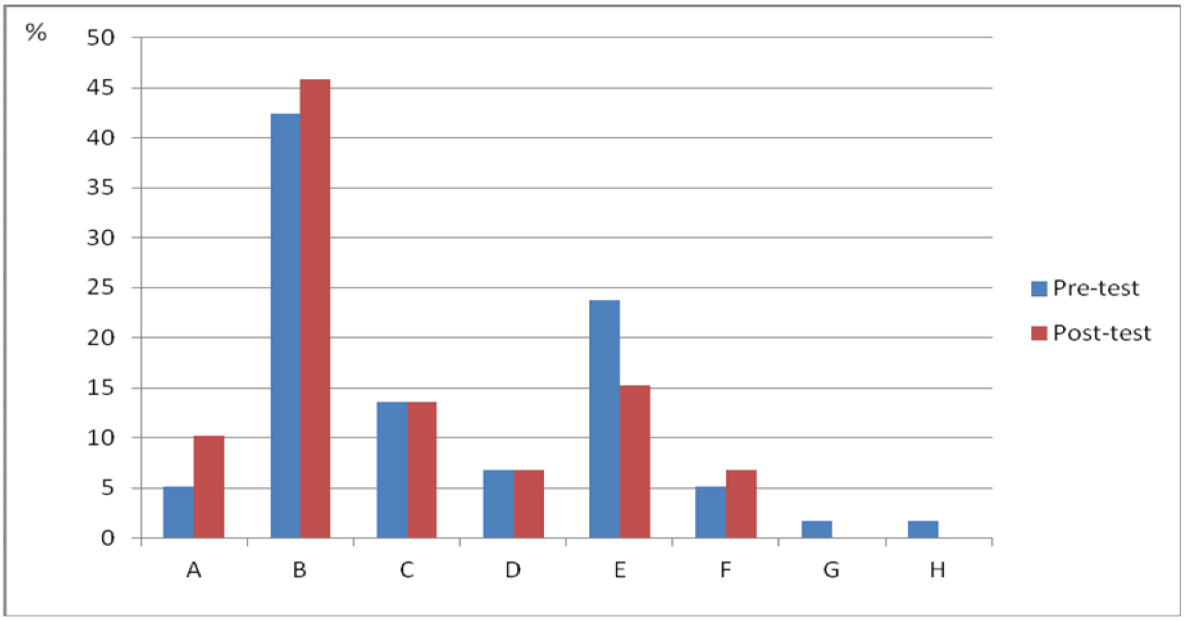

Figure 30: Pretest and post-test students' views about whether scientific theories are discovered or invented

From the data presented in the table 62 and in the graph above it can be seen that the first three choices are similar both pre and post-test. The first most chosen option was D and is considered the Realistic view, while the second and third most chosen option were E and C, respectively. Option E is considered Has Merit while the option C is considered Naïve.

The results in this study are different from the ones found in the study carried out by Manassero & Alonso (2000), in the same VOSTS item, in Spain using a sample of 654 teachers from public and private institutions, from primary, secondary and tertiary level. In their findings, the most chosen option was E with 38.9%, and the second most chosen option was F with 20.3%.

	N	***Mean***	***SE***	***Paired T Test***	***Correlation***
Pre Q_{12}	59	0.21	0.040	- 0.814	0.460
Post Q_{12}	59	0.17	0.039	(0.419)	(0.000)

Table 63: Pretest and post-test statistic results in question 12

According to the results from the statistical analysis performed and presented in the table above, it can be seen that p = 0.42, and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern pretest and post-test.

From these results it can be inferred there is no significant difference in students' answer pattern from pretest to post-test. Thus, it can be concluded that the intervention made did not contribute to change Students' opinions about whether scientific theories are invented or discovered.

In summary, this VOSTS item was about whether scientific theories are discovered or invented. The results seems to suggest that, both in pretest and post-test, students views are divided, some believing that the theories are invented, and others that theories are discovered. The idea that theories are discovered is the most accepted in the scientific community about the issue, therefore the majority of students' opinions can be considered Naïve view, and are based on the misconception about whether theories are discovered or invented by scientists.

6.7.13. Students' Opinions about the Meaning of One Scientific Idea Across Different Fields

In this VOSTS item students were required to give their opinions about whether a scientific idea has the same or different meanings across different fields. The five options presented in the table below (A to E), excluding the last three, encompass two broad positions: the first advocating that the meaning is the same and the second advocating the opposite.

The table below summarizes students' responses from the pretest and post-test:

Q_{13}: 91121 Scientists in different fields look at the same thing from very different points of view (for example, H+ causes chemists to think of acidity and physicists to think of protons). This means that one scientific idea has different meanings, depending on the field a scientist works in. **Your position, basically:** (Please read from A to H, and then choose one.)	**Pretest (N = 59)**	**Post-test (N = 59)**	**Category**
A. Because scientific ideas can be interpreted differently in **one field** than in another.	25.4	18.6	HM
B. Because scientific ideas can be interpreted differently, depending on the **individual** scientist's point of view or on what the scientist already knows. A scientific idea will have the SAME meaning in all fields:	42.4	54.2	R
C. Because the idea still refers to the **same real thing** in nature, no matter what point of view the scientist takes.	8.5	6.8	N
D. Because all sciences are **closely related** to each other.	16.9	8.5	HM
E. In order to allow people in different fields to communicate with each other. Scientists must **agree** to use the same meanings.	1.7	3.4	N
F. I don't understand.	1.7	3.4	P
G. I don't know enough about this topic to make a choice.	1.7	3.4	P
H. None of these choices fits my basic viewpoint.	1.7	1.7	P

Table 64: Pretest and post-test students' views about the meaning of a scientific idea across different fields

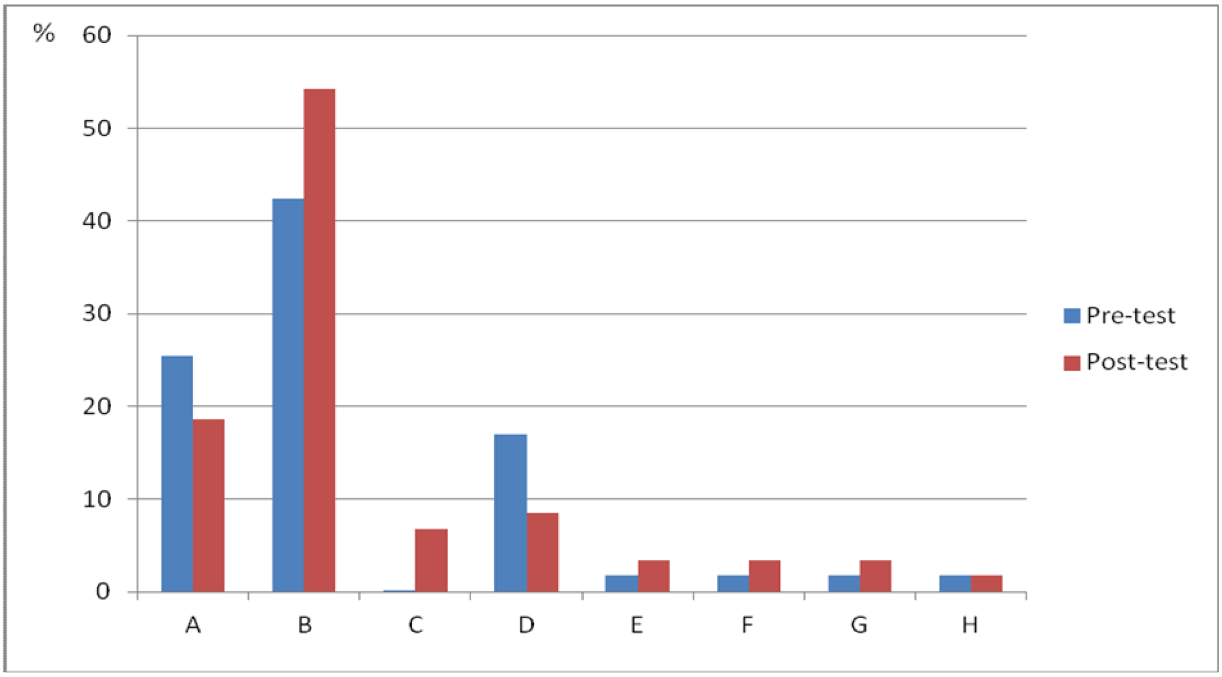

Figure 31: Pretest and post-test Students' views about the meaning of a scientific idea across different fields.

From the data presented in the table 61 and in the graph above it can be seen that the first three choices are similar both pre and post-test. The first most chosen option was B and is considered the Realistic view, while the second and third most chosen options were A and D, respectively, and both options are considered Has Merit.

The results shown in this study are contrary to the findings of the study conducted by Manassero and Alonso (2000), using the same VOSTS item. Carried out in Spain with a sample of 654 teachers from public and private institutions, from primary, secondary and tertiary level, the most preferred was the option E with 40.9% followed by the option C with 10.8%.

	N	*Mean*	*SE*	*Paired T Test*	*Correlation*
Pre Q_{13}	59	0.63	0.046	0.798	0.410
Post $_{Q13}$	59	0.67	0.050	(0.428)	(0.001)

Table 65: Pretest and post-test statistic results in question 13

According to the results from the statistical analysis performed and presented in the table above, it can be seen that $p = 0.43$, and since it is greater than 0.05 it can be inferred that there is no significant difference between the answer pattern of pretest and post-test.

From these results it can be inferred there is no significant difference in students' answer pattern from pretest to post-test. Thus, it can be concluded that the intervention made did not contribute to change Students' opinions about whether a scientific idea has the same meaning across different fields.

The statement below presents the fundament aspects that should be taken into account when judging the answers chosen:

> *"Fundamentally, the various scientific disciplines are alike in their reliance on evidence, the use of hypothesis and theories, the kinds of logic used, and much more....the exchange of techniques, information, and concepts goes on all the time among scientists, and there are common understandings among them about what constitutes an investigation that is scientifically valid. "* (AAAS, 1990, p.4).

From this statement it can assume that irrespective of the field of study the observations made should be interpreted in the same way across different disciplines.

If it is assumed that scientific ideas are expressed through laws and theories, and they are formulated from observations and inferences, respectively, then it can be inferred that there is a ground for scientists from different fields having different interpretations (inferences) from the same phenomena (observed facts).

Without contradicting these opposite positions, option B is considered Realistic because it advocates the communication between different fields, showing that above all science is a social construct.

In summary, This VOSTS item was about whether an idea has different or the same meaning across different fields. The results seems to suggest that the majority of students, both pretest and post-test, believe that scientific ideas can be interpreted differently in different fields. This idea is in accordance with what is accepted in scientific community about this issue related to the nature of science.

6.8. Summary of the Results of Pre - test and Post - test

The table below summarizes the categorization made to students' responses to the 13 VOSTS items questionnaire showing in which questions were the most chosen view.

Category of Answer	Number of Questions	Percentage (%)
Realistic	Q_4; Q_9; Q_{10}; Q_{11}; Q_{13},	38
Has Merit	Q_1; Q_2; Q_3; Q_5; Q_6;Q_7; Q_8;	54
Naïve	Q_{12},	8
Passive	--	0
Total:	***13***	***100%***

Table 66: Summary of number of questions chosen by students in pretest and post-test per category**.**

Further analysis of the data presented in the table above combined with other data the result of the intervention process showed the following patter:

- The ***Realistic View*** was first choice in **5** questions: Q_4; Q_9; Q_{10}; Q_{11}; Q_{13}, and was the second choice in 4 questions: Q_1; Q_4;Q_5; Q_8. There is no question in which the Realistic View was the third choice.
- The ***Naïve view*** was first choice only in Q_{12}, was second choice only in Q_9 and was the third choice in three questions: Q_4; Q_6; Q_{12}.
- The ***Has Merit*** was first choice in ***7*** questions: Q_1; Q_2; Q_3; Q_5; Q_6;Q_7; Q_8; was the second option in 8 questions: Q_2; Q_3; Q_6; Q_7; Q_{10}; Q_{11}; Q_{12}; Q_{13}, and was the third option in 10 questions: Q_1; Q_2; Q_3; Q_5; Q_7; Q_8; Q_9; Q10; Q_{11}; Q_{13}.

Overall, out of 39 possible desired responses in the 13 VOSTS items used for the intervention process, there were 34 (87%) among the first three choices were categorized as Realistic View or Has Merit, and only 5 were considered Naïve. Of the two desired categories, more than two third (69%) is categorized Has Merit and the other third is considered Realistic.

Taking into account that the desirable views are Realistic and Has Merit, from the results presented in the table above it can inferred that the overwhelming majority of students responses in both pretest and post-test are positive. Thus, based on this preliminary assumption it can be concluded that students' views and beliefs in the 13 VOSTS items assessed are more in line with what is accepted in the community scientific.

Despite this overall positive students response, since one of the main goals of the study was to evaluate whether the intervention made changed students' views and beliefs, the step forward was to do statistical analysis answer this question.

The expectation was that after the intervention, using the STS approach by means of inquiry type of practical work, and open-ended approach, the number of students holding Realistic view and Has Merit would be greater post-test than pretest. Even in the event where the answer pattern would be similar (the same first three most chosen options), it was expected that post-test the desired options (Realistic and Has Merit) would be much higher than in pretest.

Since the data gathered in the pretest and post-test did not show normal distribution, the statistic test carried out was for non-parametric test, to find out differences between two related sub-sample (Farber & Larson, 2010; Cohen & Manion, 2011). Both the Kolmogorov Smirnov test and the Wilcoxon signed rank test were performed because the existing data meet the pre-requisites to perform them: nominal and ordinal data, and two related samples (Cohen & Manion, 2011). The table below summarizes the result of the statistical analysis performed using SPSS package (version 20.0):

VOSTS Item	***Mean***	***Std. Deviation***	***Mean***	***t***	**Sig. (2-tailed)**
Q_1: 10111: ***Pre/Post***	-,01695	,29311	,03816	-,444	,659
Q_2: 10211: ***Pre/Post***	0,00000	,16082	,02094	0,000	1,000
Q_3: 20531: ***Pre/Post***	-,03390	,29161	,03796	-,893	,376
Q_4: 40217: ***Pre/Post***	-,01695	,37100	,04830	-,351	,727
Q_5: 40311: ***Pre/Post***	,06780	,27002	,03515	1,929	,059
Q_6: 40611: ***Pre/Post***	,16102	,45902	,05976	2,694	**,009**
Q_7: 40711: ***Pre/Post***	,00847	,14656	,01908	,444	,659
Q_8: 90111: ***Pre/Post***	,01695	,33433	,04353	,389	,698
Q_9: 90611: ***Pre/Post***	-,03390	,46298	,06027	-,562	,576
Q_{10}: 90631: ***Pre/Post***	,02542	,31382	,04086	,622	,536
Q_{11}: 90711: ***Pre/Post***	-,23729	,37550	,04889	-4,854	**,000**
Q_{12}: 91013: ***Pre/Post***	-,03390	,31981	,04164	-,814	,419
Q_{13}: 91121: ***Pre/Post***	,04237	,40777	,05309	,798	,428

Table 67: Result of statistical analysis of pretest and post-test

The results presented in the table above seems to suggest that there is a significant difference from pretest to post-test in 2 (Q6 and Q11) of the 13 VOSTS items used in the intervention, because the $p < 0.05$.

From these results, irrespective of the views students showed whether Realistic or Has Merit, it can be inferred that overwhelmingly the intervention made did not contributed to change students' views and beliefs about the STS issues assessed in this study.

In summary, it can be conclude that the intervention made seems not to have contributed to a change of students' views or beliefs about STS issues assessed, because there was no significant difference from pretest to post-test, and additionally in the seven (7) similar VOSTS item used in the survey and in the intervention process the answer pattern is exactly the same.

In order to explain the outcome of the intervention that went in opposite direction to the intended and planned, it is necessary to have a critical look at all intervention process: seminars prior to the intervention (described above in the sub-chapter 6.2. related to seminars about STS and practical work); activities during the intervention process (described above in the sub-chapter 6.5, related to learning environment), and finally to get students' assessment to these two activities , this is what is described in the next sub-chapter.

See ***appendix 12*** for the full parametric test performed using the SPSS analysis.

6.9. Results of Post-Intervention Interview

After the intervention, 12 students were randomly selected (6 from year 2012 and 6 from year 2013), and interviewed using a 6 question semi-structured interview schedule (see the ***appendix 13*** *and* ***14,*** in English and Portuguese, respectively). The aim of the interview was to get students' assessment about the STS approach in which they were engaged during the intervention period.

The interview was conducted individually to each of the 12 students following a predefined schedule made to avoid to ensure that those who were interviewed would not pass the content of the interview to other participants. Each interview last in average about 45 minutes, and in addition to the written notes it was recorded in other the get all the information provided.

After the interview, the information gathered was transcribed into a written format and translated from Portuguese to English, and finally a critical analysis was made to find categories and patterns of responses.
Below the summary of the responses given by the interviewees is presented:
(See ***appendices 15 and 16*** for Students' responses in Portuguese and the same responses translated into English, respectively):

Question 1:
When asked whether they have ever heard about STS issues and the STS approach of teaching, 7 of the interviewees said that never heard and 5 said that they had heard, and mentioned informal sources such as: community; friends, and media. After further questioning about what they knew about STS, it was clear that what they thought to be STS approach was in fact some references about the relationship between science and society rather than STS issues or STS approach of teaching and learning science.
Based on these findings it can be concluded that, as expected and assumed before starting the intervention, STS issues and STS approach were completely novel to students and almost all of them got acquitted to them for the first time when introduced during this research.

Question 2:
When asked if they had learned something important during the 12 weeks work using STS approach in a personal perspective and for the society, all the 12 interviewees confirmed that they had learned a lot. All students mentioned experiments performed that were related to problems faced by the society as the main personal gain.
Some of the statements referred to an opportunity to identify and devise solution for social problems. For Example: *"I managed to investigate and verify problems faced by the society*ò Other statements referred to the relation between the matters taught at school and the real problems that are encountered by the community. For example: *"Through STS I managed to relate scientific knowledge and the community."*

Question 3:

When asked what changed with regards to their personal lives about the relationship between science, technology and society before and after attending the STS course, all the interviewees acknowledged changes at a personal level, especially in broadening their scientific background.

The most referred response explicitly stated that after participating in the intervention they feel like scientists. Some of the statements are that corroborate with this perception are: *"Before the course I was not investigating, I was a passive subject."*

Other statements made revealed that they felt that there was an added value to their scientific background, for example: *"Previously I did not have logic knowledge and I could not solve problems faced by the society based on scientific knowledgeò*

There were also statements that emphasized the acquisition of simple and integrated science process skills, for example:

> *" I was not able to organize scientific work and doing scientific research. Now after acquiring the knowledge about science and technology I am able to do both things. "*

Question 4:

When asked how they assessed the competencies developed during the implementation of an STS approach of teaching by doing inquiry type and open ended approach of practical work and to compare it with the other ways of doing practical which they possessed before, all the interviewees unanimously referred to having gained new competencies and abilities that they did not possess before.

Most of the statements made by the students interviewed were related to development of skills to handle lab equipment, follow norms of safety in the laboratory, and how to apply science process skills when performing practical work. Example of statements made:

> *"I developed mechanisms about to use materials efficiently."*
>
> *"Today I look at science as the basic foundation of a society sustained by the technology."*

Question 5:

When asked whether, at personal level, they were content with the STS course that they were engaged in, all the interviewees answered affirmatively, but four of them were unable to elaborate more (give examples) about how it affected them on personal level.

All other statements converged on referring to the broadening of their scientific horizons, for example:

- *" I am very content because it opened up other horizons in my social life, and expanded my academic and technological views."*
- *"*I learned many things and I developed many competencies."

Question 6:

Their final comments about the positive aspects of the STS course are the following:

Related to encourage students to use knowledge gained outside classroom in a social context, for example:

- *"Expanded my views about the advantages of science and technology and it encouraged me to invent new things and take science forward."*

Acknowledgement that there is interdependence between science and technology, for example:

- *" overlapping between science and technology so that they continue to develop. "*

Acknowledgement that there is the need to use students prior knowledge, for example:

- *" In the development of science we should allow students to search for their own knowledge and bring it for discussion in the classroom."*

Negative aspects referred were not directly related to the STS course itself but the overall assessment about the impact of science and technology. Their statement were related to:

Acknowledgement of possible negative impact derived from bad use of technology to create unemployment and some environmental problems, for example:

- *"Technology reduces somehow resources in working sector increasing the unemployment and consequently the poverty. It can also harm the environment when not used properly"*

Acknowledgement that books are limited sources of information, example:

- *"I will any longer use textbooks I only use internet. "*

Overall, the assessment was positive about the STS course and about the practical work performed using open-ended approach and inquiry type. The gains referred ranged from acquisition of simple and integrated science process skills; feeling like scientists; conception change about how science is done and increased commitment and willingness to solve social problems.

6.10. Data Triangulation

The aim of this sub-chapter is to have further and in depth analysis of the results of the intervention process, primarily based on the answers from the pretest and post-test, combined with the field notes taken when students were performing practical work, and the post-intervention interview.

This approach to data processing is called triangulation, and relies on the use of multiple forms of data collection to investigate a phenomenon (Miles & Huberman, 1984; Barbour, 2001; Cohen & Manion, 2011). In addition the mixed method feature of the triangulation, once the data is collected, the triangulation is also frequently used as conclusion-verification tactic (Miles & Huberman, 1984).

The strategy used for the triangulation is to discuss the questions as cluster per area instead of discussing each question separately. Out of 8 areas covered by the 114 VOSTS items, the selected items for this research covers 4 areas.

The four areas covered by the 13 VOSTS items used in the interventions are presented in the table below:

VOSTS Area and Statement about:
1. Definitions
Q_1 - (10111): Definition of Science
Q_2 - (10211): Definition of technology
2. External Sociology of science: Influence of society on science and technology
Q_3 - (20511)*:* Whether Success in Science and Technology Depends on more Science in School.
3. External sociology of science: Influence of science and technology on society.
Q_4 - (40217): Leading Role of Scientists and Technologists to Social Decisions.
Q_5 - (40311): The Influence of Science and Technology on Creation or Solution of Social Problems.
Q_6 - (40611): Relationship between level of Development of Science and Technology with Military Power.
Q_7 - (40711): Influence of Science and Technology and Contribution to Social Thinking.
4. Epistemology: Nature of Scientific Knowledge.
Q_8 - (90111): Nature of scientific observations made by scientists.
Q_9 - (90611): Definition of scientific method.
Q_{10} - (90631): How scientific discoveries are made.
Q_{11} - (90711): Certainty or uncertainty of predictions made by scientists.
Q_{12} - (91013): Whether theories are discovered or invented.
Q_{13}- (91121): Meaning of scientific ideas across different fields.

Table 68: VOSTS area and statement of the question used in the intervention process

6.10.1. Triangulation of Data about Definition of Science and Technology

In this area two VOSTS items (Q_1: 10111 and Q_2: 10211) were selected: definition of science and definition of technology.

Students' views about science and technology in both pretest and post-test have some legitimate issues. Science is viewed as an instrument or a product rather than a process, and technology is viewed as something to satisfy social need and as the application of science.

From the observation made during the intervention, students were actively engaged in:

- searching information from internet and textbooks,
- active discussion of their ideas in groups;

- selecting materials and performing experiments without any guidance and
- making inferences from the results and drawing conclusions.

This ins confirmed in these statements made by students after the intervention in which one said:

- *"Before the course I was not investigating, I was a passive subject."*
- *"Previously I did not have logic knowledge and I could not solve problems faced by the society based on scientific knowledge. "*or a combination of both science and technology:
- *"Today I look at science as the basic foundation of a society sustained by the technology."*

Acknowledgement of overlapping between the two:

- *" overlapping between science and technology so that they continue to develop. "*

This seems to suggested that the students gained knowledge about science as a process and handled different equipment and tools to perform experiments. Therefore it would be expected that their conceptions or views about definition of science and technology would change with the intervention, but the results showed otherwise with some misconceptions about these two concepts at the core of all STS approach.

The findings of this study are similar results with others obtained in other countries on the same issues. For example, Bottom & Brown (1998), in the same VOSTS items, when studying 29 postgraduate trainee science teachers in England, the majority of the participants considered technology as application of science (option B) - the same view was held by students participating in this study both pretest and post-test.

Despite this findings, when analyzing the accomplishments and outcomes of an STS course under IOWA project, Yager & Tamir (1998), found that out of the five (5) domains covered by the STS topics, the concept domain was less or not at all affected by the intervention made, compared to other four domains: process, application, creativity and attitude.

Therefore, it can be speculated that irrespective of all the gains made during the interventions process, students need time to mature and integrate knowledge and skills acquired in order to become part of their personal beliefs and convictions to change their conceptions about science and technology.

6.10.2. Triangulation of Data about Influence of society on science and technology

In this sub-area only one (1) VOSTS item was selected (Q3: 20511). The only question used deals with the influence of society on science and technology, specially whether having more school science can lead to having good scientists, engineers and technicians.

The underlying assumption for including this question is that by using the STS approach and doing practical work in a different way that the students used to do, students would feel discontent with the science taught in Mozambican schools. The results seems to suggest that students' views before and after the intervention indicated the desired outcome.

In conclusion, it can be speculated that in order to occur students' change about whether more school science would contribute to have good scientists, engineers and technicians in Mozambique need relatively long period of time. This despite all reported and observed gains, and moreover because a school laboratory was used to perform practical work throughout the intervention period.

In conclusion, it appears that a change in perception amongst students regarding the relationship between the quality of school science and the quality of scientist, engineers and technicians in society is not apparent. Despite the reported and obvious gains, the students seemed to have found it difficult to make that link. One possible explanation could be the extensive use of the school laboratory which may have lead to confusion about the role of school laboratory.

6.10.3. Triangulation of Data about the Influence of science and technology on society

In this sub-area four (4) VOSTS items were selected (Q_4: 40217; Q_5: 40311; Q_6: 40611 and Q_7: 40711). The intervention design was aiming to boost students' knowledge about science and technology and appreciate positively their impact on different aspects of social life, namely: on food production and distribution (**Q4**), positive and negative impact of science and technology (**Q5**), contribution to military power (**Q6**), and contribution to our everyday thinking (**Q7**).

Overall students' responses on these questions, both pretest and post-test, were towards the desired direction - Realistic or Has Merit. The same answer pattern was observed in the survey on the same questions.

Taking into account these results, having a critical look at what happened in the learning environment, and based on the statement made by some students the expectation would be that students could improve their answer pattern in post-test by increasing significantly the percentage of those who chose the Realistic view or Has Merit. In light of these findings it can be speculated that students would need time to master all the gains reportedly obtained in the intervention in order to change their conceptions about STS issues that emphasize the influence of science and technology on the society.

6.10.4. Triangulation of Data about Nature of Scientific Knowledge

In this sub-area six (6) VOSTS items were selected (Q_8: 90111; Q_9: 90611; Q_{10}: 90631; Q_{11}: 9011; Q_{12}: 91013 and Q_{13}: 91121). The core issue in this area is about the nature of scientific knowledge to assess some aspects of nature of science. These six (6) questions selected are at the heart of the whole intervention process. The design and approach used in the intervention was aimed to acquire and develop science integrated process skills and to experience feeling working like a scientist.

The six questions cover issues related to: the nature of observations made by scientists (**Q_8**); scientific method (**Q_9**); how scientific discoveries are made (**Q_{10}**); certainty or uncertainty of the predictions made by scientists (**Q_{11}**); to see whether theories are discovered or invented (**Q_{12}**) and to see whether a scientific idea has the same meaning across different fields (**Q_{13}**).

Looking at students' responses in these questions, both pretest and post-test, in almost all of them the answer pattern are towards the desired directions with the three most chosen options considered Realistic or Has Merit, except in Q_{12} in which only the second most chosen option is considered Has Merit, while the 1^{st} and 3^{rd} most chosen options considered Naïve views.

These findings are based on the observations made in the learning environments, and with some statements made by students that support the development or acquisition of integrated science process skills such as:

> *" I was not able to organize scientific work and doing scientific research. Now after acquiring the knowledge about science and technology I am able to do both things. "*

Other statements related to abilities to handle lab equipment, such as:

> *"I developed mechanisms about how to use efficiently materials."*
>
> *"I developed mechanisms about the use to use efficiently materials."*
>
> *"Today I look at science as the basic foundation of a society sustained by the technology."*

The expectations were that students' views on these issues should improve significantly post-test. It can be speculated that the change of perception to take place about the nature of scientific knowledge and how scientists work requires time.

In summary, students' views and beliefs did not change from pretest to post-test as intended with the design and approach used. Students' answer pattern maintained the same from pre to post-test. However, they are leaning towards the desired directions because they can be classified as Realistic or has Merit. It appears that the intervention did not make the expected changes on students' views about the nature of science.

Chapter VII: CONCLUSIONS AND DIRECTIONS

7.1. Conclusions

In the previous six chapters this thesis presented successively the problem that prompted this study , the aims of the research and the hypothesis guiding the data collection to provide solution to the problem stated. Then, in chapter two it gave an overview about of the country to contextualize the situation in which the research was carried out, and followed the chapter three by giving a theoretical framework of most of the issues treated in this study. After that, the chapter four gave the research paradigm, the research methodology and the techniques and instruments used to collect data to answer the research questions. In the chapters five and six there was a presentation and discussion of data gathered from the survey carried out country wide - in all branches of the Pedagogical University - and presentation and discussion of data gathered from the intervention made in two tiers in one of the branches.

In this chapter it will present the final conclusions of the study, based on the partial conclusions inferred from the data collected in the chapters five and six, taking into account the theoretical framework in which the research was based and following the research methodology devised for the study, in order to answer the three research questions placed in chapter one.

The chapter starts by outlining the research questions, and tries to give extensive responses to them using the partial conclusion from chapters five and six, followed by further discussion about its implication for the study. The chapter ends by giving an overview and critical analysis about the way forward after considering the results of this study for the country and about the STS approach and STS issues in overall.

It is worthy to remember the three research questions that underpinned the whole process of data collections to find solutions for the problem posed:

1. What are Mozambican university students' views about the relationship between science, technology and society?

2. Does an STS approach of teaching involving inquiry type of laboratory work using open-ended approach contribute to change students' views and beliefs about STS issues?

3. Could an STS approach of teaching be successfully implemented in Mozambican educational system at secondary and tertiary level?

To address these questions the study made a thorough literature review about STS approach, inquiry type of practical work in open ended approach, set the learning theory underpinning the study, and made analysis of legislation and blue print documents about the Mozambican educational system. These activities formed a theoretical reference to the research design and approach devised, and combined with the results of the baseline study and the intervention process yield the conclusion of this study.

Taking these issues into consideration the main conclusions of this research are the following:

1) Mozambican students' views and beliefs about the relationship between science, technology and society are positive, they correspond to what is commonly accepted in the scientific community about the STS issues assessed in this study.

This assumption is based on the results of the survey which showed that the overwhelming majority of responses to the 13 VOSTS items questionnaire were considered Realistic or Has Merit. This results set up the baseline situation about an approach and study that have never been done in Mozambique, because it was carried out in all ten branches of the pedagogical university distributed in all provinces of the country, using 832 second year students of science or science related courses.

The possible explanation for these results is that science is universal regardless of the conditions or place where it taught. The findings of this study revealed that, in some issues Mozambican students' views and beliefs were similar to those accepted in the scientific community about the issue while in other developed countries students held misconceptions about them.

2) The result of the baseline study, beside being considered positive showed that students irrespective of the science or science related course that they are enrolled (agriculture, biology, chemistry and physics), hold the same views and beliefs about the STS issues assessed.

This assumption is based on the results of statistical analysis that showed that, only in two (Q_6 and Q_{11}) of the 13 VOSTS items that comprised the questionnaire, there was no significant difference between the courses.

The possible explanation for these results is the nature of science curricula in which students have compulsory separated science disciplines: biology, chemistry and physics throughout junior secondary school (three years) and senior secondary school (2 years).

The canonical nature of science content (focused on laws, theories and principles), the practices in the classroom (teacher-centered, and use of talk and chalk and board), and the type of assessment used (focused on rote learning with little application of knowledge), lead to the situations in which students cannot develop own ideas about science. Therefore, it is understandable to have students who went through the same science curriculum to have the same views and beliefs about these issues. The students were formatted to think that way about science.

It is important to point out that in this study, when characterizing the Mozambican curriculum, one of the aspects pointed out that could have negative impact on mastering STS issues was the nature of secondary school curriculum - separated disciplines and canonical nature of the content of those disciplines. These feature seemed to have contributed to an opposite result when assessing students views and beliefs about STS issues.

3) An STS approach of teaching implemented though inquiry type of practical work using open ended approach during twelve (12) weeks suggests that students view are positive and are more in lines with what is accepted in the scientific community about the 13 VOSTS items assessed in the intervention process.

Despite in most of the questions students' responses falling into the Realist and Has Merit, and these categories being considered positive results, according to statistical analysis comparing responses to the pretest and post-test results it seems that answer pattern did not change with the intervention made.

Although an overall evaluation of the results can be considered positive because the most chosen responses were considered Realistic and Has Merit, only in five of the thirteen questions students' responses were Realistic and in the other eight questions they were considered Has Merit. Thus, it is still necessary an improvement of students' views or beliefs in order to move from Has Merit category to the Realistic - the ideal response.

4) Based on the results of the intervention process with the experimental group in two different years it can be concluded that the STS approach of teaching proposed and implemented though inquiry type of practical work using open ended approach did not contributed to change students' views and beliefs about STS issues from pretest to post-test, except in two of the thirteen VOSTS items assessed.

In order to find possible answers for the intervention process not producing the expected outcome there was a need to look at the whole design and implementation of the intervention process, and compare with the results of similar studies using STS approach to address and assess STS issues.

The following explanation can be put forward to justify the failure of the intervention process:

- ***Duration:*** Twelve weeks is relatively short period of time for students to get to know new approaches of learning and performing practical work, master and implement them in an intensive way to yield results that would be assessed within short period of time.

There was an enthusiasm from the students for being engage in implementing a new approach of doing practical work, and get to know about STS issues, but just when their started to get use to it and get the feeling of doing research, the process had to be called off.

The fact that the intervention occurred during 12 weeks (2 weeks training seminars about STS approach and about open inquiry type of practical work, 2 weeks identifying problems and searching for solutions, and 8 weeks performing practical work) is *per se* a big burden.

In addition to that burden, all the intervention process coincided with the semester term for normal classes of their courses, and sometimes they had to make trade-offs between doing the demands of their course or engage in the activities of the intervention.

- ***Resilience to change:*** students' conceptions about STS issues are so embedded and deeply rooted in their mind that cannot be changed by simple contact with something new for them.

It is important to note that at the beginning students did not have any idea or conceptions related to STS issues, even though their views assessed through pretest were categorized as Realistic and Has Merit. It can be speculated that students used their views and beliefs about science to answer questions related to STS issues and they succeeded by giving answers that are considered acceptable in the scientific community about the issues assessed.

- ***Complexity of the task***: Students were required as a pre-requisite to have functional knowledge about STS issues and about STS approach of teaching. In addition to that they should learn more about inquiry type of practical work and how to use open-ended approach of doing practical. Both tasks were novel to them and was complicated to know in depth and apply during the intervention process.

  Examples of other studies carried out elsewhere showed that even for those who know both issues could still experience difficulties to have views and beliefs that are acceptable in the scientific community about the STS issue selected.

- ***Learning environment:*** The intervention occurred in poorly equipped laboratory without running water and no gas connection. These conditions combined with lack of other lab appliances and apparatus might have prevented students to develop some integrated science process skills, what may led to answer not accordingly to some of the STS issues assessed in the study.

  Students were learning in a natural environment, with pressure of time to accomplish the task. The interaction among the students in the group was natural, friendly and focused to solve identified problems.

Students were disputing the same equipment to perform experience, because there were not enough apparatus and instruments in laboratory, although the initial design was to set up workstations with specific types of equipments where students could pass by and perform experiments to solve identified problems.

In addition to the bad conditions in which the study was carried out, during the laboratory activities students were required to take leading role on deciding what to do, select the materials and perform the practical work according to previous preparation. It was observed that the discussions and debate within the groups were not properly developed to promote expected skills for the study.

The approach supposed to take place during the intervention process, based on self-directed learning, using constructivist strategies: invitation, exploration, proposing explanation and solutions, and taking action (Yager, 1992) did not happen as expected, only the first three stages occurred. Students were very depended on the teacher to solve small discrepancies among them.

5) By comparing students' responses to the seven common VOSTS items in the baseline study and in the intervention process, in both years and pretest and post-test, the answer pattern are similar. These findings show, on one side that all science students share the same views about science, and on the other that irrespective of the intervention made students did not change their views.

-Studies carried out elsewhere showed that of all domains covered in the VOSTS items administered the one where students showed less positive results is the conceptual domain, regarding definition of science and technology. These findings are similar to the ones reported by Yage & Tamir (1998) when evaluating the accomplishments and outcomes of an STS course under IOWA project, they found that out of the five (5) domains covered by the STS topics, the concept domain was less or not at all affected by the intervention made, compared to other four domains: process, application, creativity and attitude.

6) Based on the results of the baseline study, the results of the intervention process and taking into account the evaluation of the blue print documents about Mozambican educational system and the socio-politic context of the country it can be concluded that the STS approach of teaching can well be implemented in Mozambique.

Based on the results of this study, from the baseline study and the intervention process, it can be concluded that STS issues and STS approach of teaching are completely unknown in Mozambican educational system, nevertheless the both STS issues and STS approach of teaching for relevant for students.

This study suggests that due to its complexity the STS approach should start from tertiary institutions, like the Pedagogical University of Mozambique, rather than in secondary school. The same approach was used in Nigeria (Jegede,1988) an African country with some similarities with Mozambique.

This assumption is supported by the existence of a road map to implement the STS approach in the country: reference to constructivism as the learning theory to be used; implicitly existence of integrated science than separated disciplines as practiced now, and the openness of the country to adopt established trends in science education.

Based on this findings, and taking into account the theoretical framework devised from the literature review made, there are conditions and it is possible to introduce this approach in Mozambique, for two main reasons.

First, internal reasons - discontent with current science curricula at all levels, characterized for being not relevant and meaningful to students, based on canonical science content. In addition to that, there blue print documents and the level of organization and practices in science teaching and learning.

Second, external reasons - STS is among the top research line in science education, and it has been successfully implemented to promote scientific literacy, decision-making and active citizenship - considered priorities and goals for any educational system anywhere in the world.

7.2. Concerns and Ways Forward

Although this study was based on a case study - both the baseline study and the intervention process used students from the Pedagogical University in Mozambique, with specific characteristics of students, the study design made, the sample size used, and the rigor in controlling variables, it is believed that the results of this study are valid and can be generalized to other Mozambican students with the same science background. Furthermore, if considering science as universal irrespective of the place where it takes place, some of the findings of this study can be generalized to other places in world.

It would be recommended to have further studies about STS issues by increasing the sample size and by covering many more VOSTS items than the 19 covered in this study, and all the 8 areas of VOSTS items. Therefore, it would be worthy to compare students' views and beliefs from different scientific backgrounds: natural science, arts, humanities and languages. In addition to that, the study can be expanded to higher secondary school students with natural science disciplines are compulsory. By doing that it will form a general data base and profile about Mozambican students' opinions about STS issues.

One of the issues of concern in this study is the scoring scheme devised by the panel of judges assembled to act as experts. The process of finding consensus among the experts was based on the most chosen option criteria. It could be improved by using specific statistic test and other procedures like interview to the experts in order to find consensus and increase the validity of the final scoring scheme used to assess students' responses.

To minimize the ambiguity of the choices made by the panel of experts, there was a need to crosschecking their choices by comparing and adopting scoring scheme made elsewhere in the same VOSTS items. The assumption for this position was that they were more knowledgeable about STS issues that the panel of experts used in this study. Unfortunately this process could only be made with some of the 19 VOSTS items used in overall study: 13 in the baseline study, 13 in the intervention process, of which 7 were similar and 12 were different (6 in the baseline and another 6 in the intervention).

Despite that, it is worth to consider that the experts assembled for this study were the most knowledgeable teachers in their field at the Pedagogical University and in Mozambique, despite not being acquitted with the STS issues and STS approach of teaching. This gives a relatively reliable confidence on the work done, and shows local version of STS.

If were to repeat the study, in order to minimize the influence or other variables to the outcome of the study the following measures would be taken into account:

- To have longer period of the training about the STS issues and STS approach of teaching, and about inquiry type of practical work, using open ended approach. In the end of the training process an assessment criteria should be devised to see whether they understood it and acquired the required skills to undergo the intervention process. It would be good if this process take place couple of weeks before the intervention begin.

- The laboratory conditions should be improved with more instruments/appliances and materials to perform different types of activities related to science in general. The ideal would be to set up workstations based on the problems identified and the experiments that can be performed.
- A typical experimental design would be recommended with experimental group in which students would implementing the approach suggested and control group where students would continue with their normal activities.

The main contention in this study was to identify students' views and beliefs and classify them according to the categories devised. The results of the baseline study and the intervention show that most of students' views and beliefs are acceptable. Nevertheless, there are fewer Realistic view and many Has Merit categories. It would be recommended to carry on with this study and evaluate students' views and beliefs about the STS selected for the study.

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